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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 189
Decapod Compound Locomotive for the Minneapolis, St. Paul & Sault Ste. Marie Ry. (illustrated).... 190
Portsea Swing Bridges over the River Weaver at Northwich, England (with two-page plate)..... 190
Anderton Roller Thrust Bearing (illustrated)..... 193
Defects Experienced in Belleville Boilers in the British Navy..... 193
Education for the Subordinate Ranks of the Maintenance of Way Service..... 193
Advanced Expansion Steam-Pipe Joint (illustrated) 194
A Year's Municipal Development..... 194
Steel Clips in Steel Frame Building Construction (illustrated)..... 195
Population of Principal Cities of the United States. 195
Notes from the Engineering Schools..... 195
An Excavating and Loading Machine for Transferring Ore to Railway Cars (illustrated)..... 200
Railway Transition Curves (illustrated)..... 200
An Auxiliary Air-Compressor for Steam Engines (illustrated)..... 204
EDITORIAL NOTES..... 196
The Protection of Galveston from Ocean Storms—A Swing Bridge Design for a Site Having Insecure Foundations—The Increased Price of Coal and Its Influence on the Competition Between Sails and Steam in Ocean Freight Transport—A Sailing Ship with Auxiliary Steam Power—A New Plan for Nominating Officers of the American Society of Civil Engineers.
EDITORIAL:
Pig Iron Production, Prices and Prospects (illustrated)..... 197
LETTERS TO THE EDITOR..... 198
Sewage Sludge Disposal at Brockton, Mass.—In Defence of the Dromedary—Setting Slope-Stakes in Cross-Sectioning Earthwork—Railway and Engineering Work in Egypt—The Proposed New Method of Nominating Officers in the American Society of Civil Engineers—Stray Notes of Municipal Work—Notes and Queries.

THE QUEBEC BRIDGE OVER THE ST. LAWRENCE River will, it is stated, be rapidly pushed to completion. According to the reports, the contract for the substructure has been let to Mr. M. P. Davis, of Montreal, Que., and he has already begun work. The bridge will stretch from a point just south of the Chaudiere on the south side of the river across to Cap Rouge on the north side. Granite quarries at Riviere a Pierre, on the Lake St. John Railway, 60 miles from Quebec, have been secured. Mr. Davis estimates the quantity of masonry at 50,000 cu. yds., 5,000 of which will be finished when his men close down for the season, about Nov. 15. Besides the two abutments—one on the Quebec and the other on the Levis side—there will be two anchor piers and two river piers, the latter supporting a span of 1,800 ft. The cantilever span on the Forth Bridge is 1,710 ft., or 90 ft. short of the St. Lawrence Bridge's central span. From each abutment to its neighboring pier the distance is 400 ft., and the anchor spans are 500 ft. each. Thus, the total length of the bridge from abutment to abutment is to be 3,600 ft., or rather more than two-thirds of a mile. Mr. Davis has until Oct., 1902, in which to get the substructure built. Next May one of the inner piers is to be commenced. Pneumatic caissons, 168 ft. by 50 ft. and 50 ft. high, are to be built this winter, to be launched when required. The steel superstructure is to be the work of the Phœnix Bridge Co., and will weigh about 40,000 tons. The bridge is to have a double track. There will also be a double-track street railway and a double-track carriage way. The bridge is being built by the Quebec Bridge Co. Aid has been voted by the Dominion Parliament to the extent of $1,000,000; by the Quebec Legislature to the extent of $1,250,000, and by the city of Quebec to the extent of $300,000. The estimated total cost of the bridge is 4,000,000. Four railways are interested in the great structure.

THE GODAVARI RIVER BRIDGE at Rajahmundry, Madras Presidency, India, has been completed and opened for traffic. The bridge consists of 56 spans of 150 ft. each, and is the second longest bridge in India, being 8,400 ft. long. The Sone bridge at Dehree is 9,300 ft. long, composed of 93 100-ft. spans. The Godavari bridge was manufactured by the Butterley Co., of England, who shipped the first four spans in December, 1898, and the last four on April 20, 1900. Work was begun on the bridge in 1896. The engineer in charge was Mr. F. T. G. Walton.——Another Indian bridge of large size, the Gorga River bridge, at Turtipur, is reported to be about one-fourth finished. This bridge will consist of 18 200-ft. spans.

A LARGE ORE SHIPPING DOCK has recently been completed by the Eastern Minnesota Ry. Co. The dock is 1,500 ft. long, 65 ft. wide and 73.1 ft. high, and contains 230 ore pockets having a capacity of 250 gross tons each. The capacity of the dock is 65,000 tons of ore, all of which can be loaded into vessels in 36 hours. About 12,000,000 ft. B. M., of timber and 13,216 from 40-ft. to 60-ft. piles were used in constructing the dock.

LARGE FREIGHT VESSELS on the Great Lakes are making the carrying trade so unprofitable for small vessels that a dozen or so of the latter will be brought to the Atlantic Ocean this fall to enter the ocean trade. They will be loaded with steel and coal at the lake ports and brought through the Welland Canal before the close of navigation. After taking these cargoes to Europe, they will engage regularly in the Transatlantic trade. It is estimated that 39 steamers can be secured for this purpose, averaging about 3,000 tons in displacement. The companies most actively interested are the Carnegie and Rockefeller companies, the American Steel & Wire Co., and the Federal Steel Co.

A LARGE HYDRAULIC DREDGE for work on the Calcutta dock improvements has just been completed at the Walker Shipyards, London, Eng., after designs by Mr. Lindon W. Bates. This dredge is of the usual revolving cutter type so much used in the United States. The main dimensions of the hull are: Length over all, 128 ft.; length between perpendiculars, 124 ft.; breadth, extreme, 30 ft.; depth, molded, 8 ft. 9 ins. A raised forecastle deck and bridge deck are provided, and aft of the bridge deck a quarter deck. The boiler room occupies the center of the vessel, with coal bunkers of a total capacity of 70 tons on each side. Under all the machinery and boiler spaces a double bottom is built. The suction ladder is placed in a well at the bow. The machinery comprises the main pumping engine, driving the sand pump, the propeller, the cutter engine, a hoisting engine for raising and lowering the suction ladder, and a similar engine for lifting the spuds, steering engine and the usual auxiliary machinery, with the addition of a force pump, which supplies filtered water to all bearings placed under or in contact with sandy water, so as to exclude grit from the working surfaces. The cutter consists of 12 knives made of steel plate, and forming a hollow cylindrical milling cutter. The dredging pump has a steel runner and a cast-iron casing, made in five pieces. The main engine, which is coupled directly to the centrifugal pump, is of the usual vertical marine compound type. Steam is supplied to all the engines from a Babcock & Wilcox marine boiler, with four furnaces adapted for using Indian coal. The spuds are at the stern, and are square spars of Oregon fir, guided in well ways built into the hull, and are fitted with cast-steel shoes. The capacity of the dredge is from 300 to 1,000 cu. yds. per hour, according to the character of the material handled and the distance to which it is discharged. Satisfactory dock and sea trials were made with the dredge before it left the Tyne. A speed of 8 knots was developed on trial.

THE IMPROVEMENT OF MANILA HARBOR is contemplated in a bill which is being prepared by Mr. Wright of the Philippine commission. The bill calls for an appropriation of $1,000,000 for the work.

THE DAMAGE TO THE BATTLESHIP "OREGON," which grounded in the Miau-Tau Straits and injured her bottom, is reported to be much more serious than was at first thought. It is stated that there are holes in the bottom plates through which a man can crawl, and that the keel has been broken and forced at least 2 ft. out of line. It is estimated that the repairs will take four months, and will cost $250,000. The vessel has been ordered home for a complete overhauling.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred at Mounds, Ill., Sept 12, on the Illinois Central Ry. A special car, occupied by a troupe of female minstrels, was attached to a fast mail train. As the train was entering the yards at Mounds a wheel of the special car broke, wrecking the car and killing nine persons and injuring six.

A STRIKE OF ANTHRACITE COAL MINERS was ordered by the executive board of the United Mine Workers of America on Sept 17, and on Sept. 19 it had involved about 90,000 of the 140,000 miners normally working in the anthracite region of eastern Pennsylvania.

A PECULIAR ACCIDENT FROM LIGHTNING occurred on July 14 at Easthampton, Mass., during the construction of a brick chimney for the West Boylston Mfg. Co.'s cotton mill at that place. The staging used in the work of building the chimney was so constructed as to permit the use of a cable and large bucket, in which men were hoisted to their work in the morning, a small hoisting engine near by furnishing power for operating the cable. During a heavy thunder storm, as the workmen were getting into the bucket to be lowered to the ground, the engineer having one hand on the throttle and the other on the brake, watching for the last man to get in, the lightning struck the staging of the chimney, splintering a few pieces of wood at the top and following down the cable on the opposite side of the sheave from the bucket, grounding at the hoisting engine, and in doing so, stunned the engineer, knocking him down. He was standing on a plank at the time, which probably partially insulated him. After a few minutes he came to and lowered the men in safety to the ground. The chimney was not injured. The temporary lightning rod, which the builders had unconsciously provided in their hoisting cable, had apparently protected the structure.

TWO OLD-TIME LOCOMOTIVE WORKS are to be abandoned and dismantled this fall. The Rogers Works, at Paterson, N. J., and the Kingston Works, at Kingston, Ont. An attempt was made to secure local capital and enable the Rogers Works to be so improved as to enable them to continue in business; but it was unsuccessful.

THE PINTSCH GAS BUOY is now made so as to act as an automatic bell buoy as well as a beacon. The ordinary bell buoy is silent when the surface of the water is smooth, which often occurs during a fog, when the warning of the bell buoy is most needed. The new Pintsch gas buoys hold sufficient gas to burn from 80 to 365 days without refilling, and a bell is sounded automatically every 15 seconds whether the water is rough or smooth.

THE NEW OIL PIPE LINE from Baku to Batoum, 560 miles long, has been completed for a distance of 145 miles. The 8-in. wrought-iron pipe is to run parallel to the Trans-Caucasian Railway, and is being laid by the engineers of that line. The first section has three pumping stations, each station being equipped with two compound high-duty engines, with 21-in. and 42-in. steam cylinders, with 24-in. stroke. These pumps work against a pressure of 650 lbs. per sq. in., with a steam pressure of 150 lbs., and the duty of each pump is fixed at 416,275,200 gallons of oil pumped per year.—Engineer's Gazette (London).

ACETYLENE FOR LIGHTING RAILWAY CARS is discussed in the June number of the "Journal of the Association of Engineering Societies" by Mr. A. Lipschultz, of the Great Northern Ry. The use of gas generators upon the trains is not feasible. With small generators the heat from the chemical reaction renders the gas impure, and this leads to the stopping up of pipes and burners. It is difficult to charge a generator without creating odors and much care is required of the trainmen. The gas must be generated at central stations and compressed into tanks. The author discusses the effect of pressure upon the safety of acetylene. In Europe a mixture of acetylene and Pintsch gas is used and it has been found that there is no danger of explosion when a tank of this mixture at 150 lbs. pressure is heated to the dissociating temperature of pure acetylene. When pure actylene was heated to a temperature of 1,400° F. an explosion took place which demolished the tank. A tank was made with soft soldered seams which opened at about 380° F., thereby letting the gas escape. If the piping is also made of material which will melt at about 400° F. all danger of explosion in case of wreck is obviated. One man can take care of a central station generating 10,000 cu. ft. of gas daily, which is equivalent to more than 30,000 cu. ft. of Pintsch gas.

THE PRODUCTION OF HIGH TEMPERATURES by the combustion of aluminum is the subject of an article by Dr. Hans Goldschmidt in a recent issue of "Glücklauf." Finely pulverized metallic aluminum, if thoroughly mixed with the oxide of some metal, such as powdered iron ore, burns with an intense heat, probably over 2,000° C., the resulting products being aluminum oxide and metallic iron. The mixture must be raised to a very high temperature before the reaction will take place. For this purpose a mixture of barium peroxide and aluminum, which may be ignited with a match flame, is used. The intense heat may be used for welding iron or steel rails and pipes. The ends to be joined, having been cleaned, are pressed together and surrounded by a mold, into which the molten products of the combustion of the above mixture are formed. After cooling the latter may be broken off with a hammer, leaving a smooth joint. The aluminum oxide, or alumina, is very hard and is suitable for polishing or grinding. Powdered aluminum may be used for the reduction of metals which it has not before been possible to isolate completely. Among these are chromium and mangnese. The use of the former metal free from carbon in chrome steel gives a metal markedly differently from ordinary chrome steel.

A POWER DEVELOPMENT PROJECT of large proportions is now being carried out on the San Juan River between the cities of Peral and Chihuahua, Mexico. A dam will be constructed 250 ft. long and 150 ft. high, which will form a lake 15 miles long with an extreme width of 3½ miles. Power will be transmitted to Peral, 40 miles away, and to Chihuahua, a distance of 80 miles. It is said that over 6,000 HP. has already been contracted for in these cities.

THE LIQUID AIR PATENT interference case of Tripler vs. Ostergren & Burger, which was decided in favor of the former some months ago by the primary tribunals, has just been passed upon by the Commissioner of Patents and the former decision is sustained. The apparatus of both these inventors has been illustrated in Engineering News.

WIRELESS TELEPHONY has been accomplished over a distance of eight miles at sea, according to an announcement made by Sir William Henry Preece, Consulting Engineer of the British Post-Office, at the annual meeting of the British Association for the Advancement of Science lately held at Bradford, Eng. He said, further, that it was a practical commercial system, and might be extended to communication between ships and shore.

DECAPOD COMPOUND LOCOMOTIVE FOR THE MINNEAPOLIS, ST. PAUL & SAULT STE. MARIE RY.

In spite of the enormous increase in train loads within the past few years, the use of the decapod type of locomotives for heavy freight service is still quite exceptional, as engines with four pairs of driving wheels have in general been found equal to all demands, and the tracks are strong enough to carry the engine wheel loads so distributed. We illustrate this week, however, a decapod engine recently built by the Baldwin Locomotive Works, Philadelphia, Pa., for the

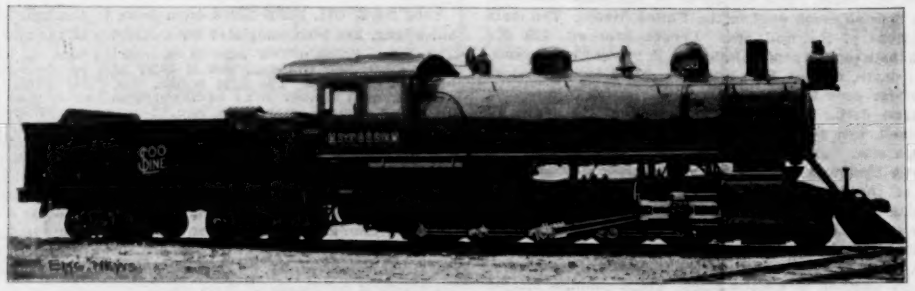


FIG. 1.—DECAPOD COMPOUND FREIGHT LOCOMOTIVE; MINNEAPOLIS, ST. PAUL & SAULT STE. MARIE RY.

E. A. Williams, Mechanical Superintendent.
Baldwin Locomotive Works, Builders.

Minneapolis, St. Paul & Sault Ste. Marie Ry. This engine is to work between Minneapolis and Pennington, Wis., 165 miles, the maximum grade on this division being 1.2%, with ruling grades of 0.8%, and the guaranteed train load over the ruling grades is 2,000 tons, exclusive of engine, tender and caboose. The following table shows the comparative dimensions and weights of this new decapod engine, the four-cylinder compound decapod of the Erie Ry. (which was a feature of the railway exhibit at the Columbian Exhibition), and the heaviest engine in the world, this last being a simple engine of the consolidation type:

	M.,St.P. & S. S. M. Ry.	Erie Ry.	P.,B. & L.E. Ry.
Type of engine....	Decapod.	Decapod.	Consolidat'n
Driving wheels ...	4 ft. 7 ins.	4 ft. 2 ins.	4 ft. 6 ins.
Whibase, driving	19 " 4 "	18 "10 "	15 " 7 "
W't, on drivers...	184,360 lbs.	170,000 lbs.	225,000 lbs.
Total engine	207,210 "	192,500 "	250,300 "
Engine & tender	327,210 "	310,000 "	391,400 "
Cylinders, h. p. ...	17 × 32 ins.	16 × 28 ins.	24 × 32 ins.
Cylinders, l. p. ...	28 × 32 "	27 × 28 "	.....
Boiler, diameter ..	5 ft. 6⅝ ins.	6 ft. 2 ins.	7 ft. 4 ins.
Firebox, length....	11' 10¹⁵/₁₆"	10' 11½"	11 " 0 "
Width.	3 ft. 5¼ ins	8 ft. 2⅛ ins.	3 " 6¼"
Tubes, number ...	344	354	406
Diameter	2⅜ ins.	2 ins.	2¼ ins.
Length	15 ft. 7 ins.	11 ft. 11 ins.	15 ft.
Htg. surf., tubes..	2,791.8 sq.ft.	2,208.8 sq.ft.	3,564 sq.ft.
Total	3,015.7 "	2,443.1 "	3,805 "
Grate area	37.5 "	89.6 "	36.8 "
Water in tank....	7,000 galls.	4,500 galls.	7,500 galls.
Coal on tender....	20,160 lbs.	14,000 lbs.	28,000 lbs.
Date in Eng. News	This issue.	June 15, '93.	June 21,1900

The new engine, shown in Figs. 1 and 2, is a four-cylinder compound, of the Vauclain system, and has an extended wagon-top boiler and a radial-stayed firebox placed above the frames. The springs of the truck and the two leading axles are connected to form one system, while the other three axles form an independent system. The springs of the first three driving wheels are placed directly over the boxes, but yokes over the boxes of the two rear axles are connected to inverted springs seated in the frame. The eccentric rods are quite short, the link being behind the second driving axle. The general dimensions of this engine are given below in our standard form:

Dimensions of Four-Cylinder Compound Decapod Freight Locomotive; M.nn., St. Paul & Sault Ste. Marie Ry.

Running Gear:
- Driving wheels (10), diameter ..... 4 ft. 7 ins.
- Truck wheels (2), diameter..... 2 " 6 "
- Tender wheels (8), diameter ..... 2 " 9 "
- Driving wheel centers ..... Cast steel.
- Truck wheels and tender wheels..... Chilled.
- Driving-wheel tires secured.... Shrinkage and shoulder.
- Engine truck..... Swing center.
- Journals, driving axles, main, 9½×12"; others, 8½×12"

Wheelbase: Driving ..... 19 ft. 4 ins.
- Total engine ..... 28 " 0 "
- Tender..... 19 ft. 8 ins.; engine and tender. 57 " 4 "
- Engine truck-pin to c. of leading axle..... 8 " 8 "
- Wheels having blind tires..... Third (main) pair.

Cylinders: No. ..... Four.
- Diam. & stroke: h.p. (2), 17×32 ins.; l.p. (2), 28×32 ins.
- Connecting rod, length between centers ..... 9 ft. 5⅝"
- Side rod ..... Solid ends.

Weight in Working Order:
- On driving wheels ..... 184,360 lbs.
- On truck wheels ..... 22,850 "
- Engine, total ..... 207,210 "
- Tender, loaded, about..... 120,000 "
- Water in tank..58,500 lbs.; in boiler..... 24,000 "
- Coal on tender ..... 20,160 "
- Weight piston and rod: H. p....460 lbs.; l. p...640 "
- Crosshead,720 lbs.; main rd,902 lbs.; side rd,963 "

Valve Gear: Type ..... Link motion.
- Ports (circular), steam..... 29⅝ × 1½ ins.
- Exhaust ..... 29⅝ × 4½ "
- Bridges, width 2¾ & 3 ins.; eccentrics, throw ..5¾ "
- Slide valves, style .Piston; max. travel..... 5¾ "
- " inside lap (negative): h.p.,⅛-in.; l.p.,⅛-in.
- " outside lap ..... h.p.,⅛-in.; l.p.,⅝-in.
- " lead, full forward gear..... None.
- " full backward gear (both cylders)..⅛-in.

Boiler: Type..... Extended wagon-top.
- Barrel, diameter inside smallest ring..... 5 ft. 6⅝ ins.
- Dome, diameter ..... 2 " 7½ "
- Thickness, barrel plates ..... ¾-in. and 11/16-in.
- " smokebox tube-plate..... ½-in.
- Horizontal seams ..... Sextuple riveted.
- Circumferential seams ..... Double riveted.
- Joints..... Butt; rivets, diam...¼ & 1⅛ ins.
- Height from rail to center line..... 8 ft. 11 "
- Length of smokebox, including extension....5 " 3½"
- Does smokebox arrangement conform to M. M. Assoc. rules?..... Yes.
- Form of spark arresting device..M. M. Assoc. standard.
- Injectors (2) ..... 1 Sellers; 1 Ohio.
- Working steam pressure..... 215 lbs.

Firebox: Type ..... Radial-stay; above frames.
- Length, inside ..... 11 ft. 10¹⁵/₁₆ ins.
- Width, inside ..... 3 ft. 5⅝ ins.
- Depth at front.6 ft. 5⅝ ins.; at back.....6 " 4 "
- Thickness, side plates, 5/16-in.; back plate..... 5/16-in.
- " crown plate..⅜-in.; tube plate..... ½-in.
- Crown stays..... Radial; grate bars..Rocking; drop.
- Is fire-brick arch used?..... Yes.
- Stay bolts..Drilled; diameter..1-in.; pitch (max).4 ins.
- Water spaces, width at front.4 ins.; back & sides.3½"

Tubes ..... Iron; No..... 344
- Thickness....No. 11 W. G.; Pitch..... 2⅜ ins.
- Diameter, outside ..... 2 "
- Length over tube plates..... 15 ft. 7 "

Heating Surface and Grate Area:
- Heating surface, tubes (exterior area)....2,791.8 sq. ft.
- " " firebox ..... 223.9 "
- " " total ..... 3,015.7 "
- Grate area ..... 37.5 "

Miscellaneous:
- Exhaust nozzle (single), diameter..... 5½ ins.
- Exhaust nozzle,distance below c. line of boiler..3½ "
- Smokestack, diameter at top and base..... 17¾ "
- " height above smokebox..... 2 ft. 7½ "
- " height above rail..... 14 " 5 "
- Capacity of tender tank..... 7,000 galls.
- Capacity of coal space ..... 20,160 lbs.
- Brake fittings..... Westinghouse American.

This engine was guaranteed to haul a train load of 2,000 tons behind the tender on an ascending grade of 0.8% (compensated for curvature) at a speed of six miles per hour. The accompanying table, prepared by the officers of the railway company, shows that the guarantee has been fulfilled, and with a low fuel consumption. The table shows the performance on three days in August, and for Aug. 26 seven miles are omitted on account of an assisting engine helping the train over a grade of 1.3%. This record is particularly interesting at this time, as railway managers are watching for the results obtained with the large engines which are now being introduced for heavy freight service.

Performance of Compound Decapod Locomotive No. 900; M., St. P. & S. S. M. Ry.

Date	Aug. 21.	Aug. 22.	Aug. 26.
Distance run, miles..	111.0	111.0	111.0
Train load { Net, tons..	1,205.9	1,298.8*	1,2[illegible]7
Train load { Tare, tons	790.7	937.47	788.05
Train load { Total, tons	1,996.6	2,236.27	2,01[illegible]75
Cars { Loaded	58	60	58
Cars { Empty	0	6	0
Ton-miles	221,622.6	222,782.8	223,[illegible]25
Coal used, tons.....	11.1150	11.425	10.1450
Pr 10,000 tn-mls,lbs.	1,044	1,007	900

*Maximum.

PONTOON SWING BRIDGES OVER THE RIVER WEAVER, AT NORTHWICH, ENGLAND.*

By John Arthur Saner, M. Inst. C. E.†

(With two-page plate.)

The River Weaver forms the great waterway of Cheshire. Although the length of the canalized portion is only 20 miles, a very large traffic is carried on by means of barges of capacities varying between 25 tons and 350 tons; their size being only limited by that of the locks, which are 220 ft. × 42 ft. 6 ins., the navigable depth of the river, 10 ft. 6 ins., and the headway under the bridges. On the completion of the works described in this paper the minimum headway will be 55 ft., with one exception, the Hartford rural-road bridge; every effort is, however, being made to secure its removal, and thereby to complete the scheme inaugurated in 1865, to make the river available for small

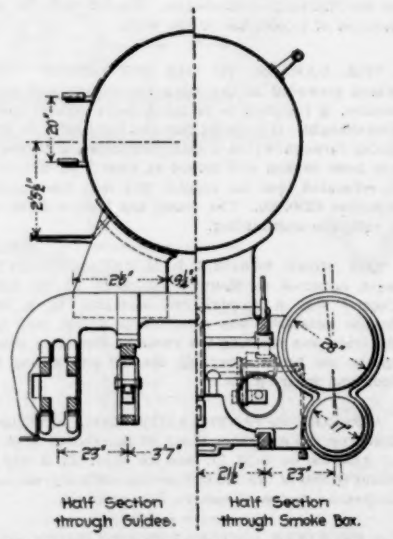


FIG. 2.—CROSS-SECTIONS OF DECAPOD COMPOUND FREIGHT LOCOMOTIVE.

coasting vessels, and save in many cases the cost of transhipment at Liverpool.

In its course through the salt-districts the Weaver passes through the subsiding areas, and, with the exception of the Northwich bridges, all the permanent works have been removed, at great expense and after several extensive alterations, to firm and sound ground. The Northwich bridge would have been removed to a better site long ago, but it forms a portion of the main road (the Roman Watling Street) from Chester to Manchester, with valuable property on both sides of the river, and the vested interests are so great as to preclude any idea of diversion. For many years this bridge, which was a plate-girder structure of 90 ft. span, had caused, owing to the subsidence of the district, great inconvenience to the river-traffic through the constantly decreasing headway. The average yearly loss of headway for about 16 years has been 4½ ins. in the locality of this bridge, so that the house property is about 6 ft. nearer the water-level than formerly. It was im-

*Abstract of a paper read before the Institution of Civil Engineers, Jan. 23, 1900.

†Engineer Weaver Navigation, Northwich, England.

permission to maintain the full headway for present traffic; the author and his predecessors in the office of engineer to the Weaver Trustees, had accordingly from time to time raised the girders. The streets in the immediate neighborhood could not, however, be raised in a corresponding manner without partially burying or raising the adjoining houses, so that the road-gradients became as steep as 1 in 11. It was also desirable, in view of coasting vessels with fixed masts using the river, to do away if possible with any form of fixed bridge.

The problem of erecting an opening bridge on such a site was no easy one, and among the existing forms of movable bridges the author was unable to find a type exactly suitable to the case. The main points to be secured were: (1) The sectional area of the river must not be unduly diminished; no central pier was therefore admissible, as widening the river—owing to the value of the adjoining property—was not possible. (2) A continuous towing-path must be provided. (3) The subsiding ground necessitated a form of structure easily adjustable. (4) The structure must allow for floods, drought and ice. (5) There must be as little interference as possible with the road-traffic, as, apart from the fact of the bridge forming part of the main road between Chester and Manchester, there was no other bridge across the river within two miles in each direction. The fifth point was provided for in the Weaver Act of 1893 by Parliamentary powers being granted to the trustees for the erection of two swing-bridges, some distance apart, so that one bridge could always be available for road-traffic. The second point was overcome by making the long end of the swinging portion span the towing-path as well as the river: this caused the tail end to be somewhat shorter than the usual practice. The sectional area of the waterway was preserved as far as possible by carrying the towing-path on open piling and lengthening the span to the extreme limit.

The form of bridge finally adopted by the author is shown in Fig. 1, and consists essentially of: (1) A pair of bow-string lattice girders carrying the road and footways. (2) A sealed circular pontoon or buoy, placed under the center of gravity of the superstructure, and suitably and rigidly connected thereto, in such a manner as to be always submerged in the river, and capable of being turned with the superstructure. (3) A group of cast-iron screw-piles surrounding, but clear of, the pontoon, and carrying a gridiron girder, which in its turn carries the bottom roller-path; cup-castings and adjustable screws are inserted between the heads of the piles and the girder.

The pontoon is placed under the center of gravity of the superstructure, and is rigidly connected with it, so that it exerts an upward pressure equal to the buoyancy due to its displacement; the pressure is, however, less than the aggregate weight of the superstructure and connections by a quantity which can be varied at will within certain limits. The remainder of the weight of the superstructure rests on the roller-paths, and is conveyed by the gridiron girder to the piles and thence to the ground. For example, if the total weight of the superstructure, connecting girders and shell of pontoon is 303 tons, and the normal buoyancy of the pontoon 255 tons, the weight remaining on the rollers and piles is 303 tons — 225 tons = 48 tons. In the event of adjustment being required, therefore, instead of 303 tons only 48 tons have to be dealt with, and even this can be reduced to 28 tons by emptying the upper part of the pontoons. The pile-heads are fitted with screws by which the gridiron girder can be raised or lowered, so that a daily adjustment can be effected if required—a by no means improbable contingency. The pontooon acts as a low-pressure hydraulic ram, and not only facilitates adjustment but materially reduces the friction on the rollers when turning.

In order to put the principle to a practical test, the author obtained in 1893 the sanction of the Weaver trustees to convert one of the numerous occupation bridges on the navigation which was undergoing alterations. Although intended for cattle-traffic only, the bridge was double-ended, 10 ft. wide, 92 ft. long, and spanned two 40-ft. openings. By placing the empty shell of an old boiler under the center of gravity, the friction on the rollers was so reduced that one man could turn it through 90° in 30 secs., but on partially filling the pontoon with water it soon became impossible for two men to move it. The result was very satisfactory; and the bridge—which was completed early in 1893—continuing to work freely and well, and to require only ordinary attention, it was determined to erect the much larger and more important works described in this paper.

The pontoon, Fig. 5, both of the experimental and new bridges, has a watertight deck situated about 1 ft. below normal water-level. The portion above this deck is open to the river through scuppers provided with valves, so that the water rises and falls according to flood or drought; the portion below this deck is, however, empty and sealed, and has, consequently, a constant buoyancy whatever the level of the water outside, provided such level does not fall more than 1 ft. below the normal. There is no danger, therefore, of the bridge being lifted off its seatings. In the new bridges the pontoon is surrounded by a casing of timber piling, and can be entirely covered in during severe frost, though no trouble has hitherto been experienced from ice at the experimental bridge, it having been always found possible to break it away as it is formed. The timber screen serves, however, the additional purpose of keeping sand and detritus from collecting under and around the pontoon.

It was at first intended to depend entirely on manual labor for the several movements in connection with swinging; but, owing to the increase of weight necessitated by the requirements of the Act of Parliament, it was decided to provide additional gearing, actuated by power. There again arose the difficulty of subsidence, and the author decided, after considering the different powers at his disposal, viz., gas, steam, hydraulic pressure and electricity, to adopt the last named, although, so far as he was aware, it had not previously been used for the purpose of bridge-turning in England. This power appeared to the author to be eminently suitable under the circumstances, the cables not being liable to breakage, as would be the pipes required for any of the other powers. It was therefore decided to adopt motor-driven gearing not only for the swinging-motion but also for the withdrawal of the wedge-blocks upon which the ends of the bridge rest when across the river.

When the bridge is open for river-traffic, "safety" gates, Figs. 8 and 9, are closed at each end. These gates, with the exception of the two at the tail end of the Town Bridge, the more northerly of the two new bridges, are moved by hand; as it was feared that, if moved by machinery, they might prove a source of danger to passengers who happened to be within reach and not on the alert at the time of closing. The bolts fastening these gates open are so arranged that the bridge cannot be swung until they are withdrawn. The swinging gates, which weigh about 31 cwt. each, are hung on a circular ball-bearing at the top of the centre column and are connected by a cross shaft and quadrants under the roadway; they can be easily closed or opened with one hand. The tail-end gates for the Town Bridge are shown in Figs. 8, and are moved by two 4-B. HP. electro-motors controlled by a switch placed near the cabin-door, in order that the man in charge can warn anyone in the way. The two bridges were built from the same drawings, and as the only difference is that one gives a clear headway of 16 ft. at normal water-level, and the other 10 ft., the same description will suffice for both.

The abutments of the second or south bridge, now called Navigation Bridge, had to be commenced de novo, but in the case of the Town Bridge, the old abutment on one side was made use of. The abutments and pontoon chambers, as will be seen from Fig. 1, consist of short compact concrete and masonry walls, built with broad bases and tied through with chain-cables so as to form as solid and homogeneous a mass as possible. The amount of concrete and masonry was kept at a minimum, as experience shows that, however strongly they may be built, they are liable to destruction by subsidence. The remaining portions, including the whole of the pontoon-chamber and tail-end abutment of the Town Bridge, together with the towing-paths and protection-works, are constructed chiefly of timber. Where necessary, the piles are V-grooved—a form which the author has used largely elsewhere on the Weaver with very satisfactory results.

Pontoon Chamber.—Considerable difficulty was experienced in preparing the pontoon chamber for the Navigation Bridge owing to the great depth of fine wet sand, but it was finally excavated to the required depth of 15 ft. below normal water-level. The concrete wall was inserted in short lengths, each length being surrounded by grooved piles and excavated by means of a grab dredger, as it was found impossible to pump the foundation dry. On the required depth being reached, the concrete was lowered in bags or by means of a drop-bottom box. In computing the stability of the wall, allowance was made for its being surrounded with water, and it was made of sufficient weight to resist the pressure of the earth, although nearly submerged. To relieve the pressure on the inner wall, a fixed span about 29 ft. 3 ins. long, supported on wrought-iron columns at the bridge end, and a second retaining wall at the shore end, were built. This second wall was founded on a stiff bed of clay, and was given a very broad base. In the case of the Town Bridge, a puddled cofferdam was constructed to enclose the old abutment, which was easily and successfully removed and the new work was substituted for it. Chain-cables of ¾-in. and 1-in. iron were embodied in all the concrete walls to give lateral strength.

Screw Piles.—The next operation in each case was to screw in the cast-iron piles, Fig. 6. These are 2 ft. 6 ins. in diameter, 1¼ ins. thick, and in lengths of 10 ft., the screw-blade being 4 ft. 6 ins. in diameter, and having a pitch of 10 ins.; the lower end of the pile is provided with a serrated edge. There are ten piles at the Navigation Bridge, and seven at the Town Bridge surrounding the pontoons, and there are three similar piles 1 ft. 6 ins. diameter, carrying the receiving girder for the nose end of each bridge. These were all screwed into the ground 26 ft. below water-level, and were then filled with cement concrete. At times the progress was so slow as to be only ⅛-in. per revolution, one revolution occupying an hour in the case of the larger piles. This rate of progress was, however, increased to as much as 4 ins. per revolution by using a water-jet introduced by means of a pipe down the center of the pile. It was found that these piles in which the jet had been used were entirely emptied of sand, so that there was nothing to prevent their being properly filled with concrete. It was computed that in the very unlikely event of the entire failure of the pontoon, the greatest pressure on any one pile would not exceed 4.6 tons per sq. ft., provided the blades of the screw remained intact.

Pontoons.—The pontoon for each bridge is made in four quadrant-shaped pieces, Figs. 1 and 5, forming together a circular buoy 30 ft. in diameter and 12 ft. 6 ins. in depth from the upper deck to the dished bottom. The four pieces are placed 6 ins. apart, and are connected at the top by a circular girder, D, riveted to the upper edge of what may be termed a "bulwark" rising 2 ft. 6 ins. above the deck, and 1 ft. 6 ins. above water-level. This girder is provided with horizontal wheels, which would come in contact with a second circular girder, E, should there be any severe displacement of the structure whilst turning. The girder E also forms a bracing for the cast-iron piles. The plating of the pontoons is ⅜-in. steel, with 3-in. × 3-in. × ⅜-in. angle-iron frames, and the flat vertical sides are stiffened with vertical gussets. The bottom is dished, and the deck is flat, being provided with manholes and valves for regulating the water. At each bridge a double-action hand-pump is fixed for keeping the pontoon clear of water. All the pontoons were tested before launching by being filled with water, and so far have proved perfectly tight.

Connecting Girders.—The connections between the pontoon and the superstructure are shown in Fig. 2. The carrier-girders, A, B, are double-web box-girders, built of ½-in. plates, and stiffened with angle-bars and gussets. The whole upward pressure of the pontoon is by this means concentrated under the six central verticals of the superstructure, the two central verticals bearing 46.9 tons each, and the four others 23.45 tons each.

Superstructure.—The superstructure consists of two braced girders 112 ft. long, with a cambered top boom, the height over the center of gravity being 17 ft. The roadway, which is 19 ft. 6 ins. wide, is placed between the main girders, and consists of steel trough-flooring covered with oak planking, laid on felt to deaden sound. The footways are of oak planking 4 ft. 6 ins. in clear width, and are carried outside the main girders by cantilevers.

Rollers and Paths.—A circular box-girder, F, Fig. 1, 2 ft. deep and 27 ft. 6 ins. in external diameter, is fixed to the underside of the lower boom and distributes the weight to the upper portion of the cast-iron roller-path. This in turn rests on a live ring of 72 conical rollers, each provided with an internal flange, as shown in Fig. 3. The rollers and lower roller-path are carried by girder G, a star or gridiron-shaped girder 2 ft. deep and shaped in plan as shown in Fig. 4. Each ray of the star has a hemispherical cast-iron foot which fits into a corresponding steel socket of somewhat larger radius, Fig. 7, and forms the head of the pile. Each of these cast-steel sockets is fixed on four screws, 4½ ins. in diameter, passing through bosses on the top length of pile, and adjustable vertically by means of nuts. Should, therefore, the girder G, with its roller-path, subside, owing to the subsidence of the piles, it is only necessary to adjust the screws; and eventually, when the screws are fully out, to insert a fresh short length of pile under the top casting.

End Girders and Wedges.—The ends of the bridge when across the river are carried on wedge-blocks fixed to substantial box-girders resting on the cast-iron piles, in order that the whole piece may be adjusted for level as required. The circular end-pieces on the swinging portion are finished off with cast-iron, but on the shore are oak planks, in order that any "jamming" may at once be alleviated by cutting away the timber.

Hand-Turning and Wedge-Drawing Gear.—By means of a simple rack-and-gearing arrangement, partly shown in Fig. 3, the bridge can be swung by one man in about 4 mins. on a calm day. It would be necessary, however, in case of the electric power being off at the time of a high wind, to have additional assistance. The wedges can also be actuated by hand, a hand-wheel being first fixed on the vertical shaft, Fig. 14. At a special trial made for the purposes of this description one man opened the Navigation Bridge in 3 mins.; he only managed to get it back about half-way, however, as there was a light breeze from the south. Two men then assisted him, and the whole movement of the bridge occupied 7 mins. 15 secs. There are 95 turns of the handle each way. The complete operation, by hand-power only, of closing the gates, withdrawing the wedges, swinging the bridge, replacing the wedges and opening the gates again to road traffic, occupied 8 mins. 50 secs. This was done twice.

Electrical Installation.—The most convenient supply of electricity was to be obtained from the Northwich Electric Supply Company, whose installation consists of three 100-HP. Crossley gas-engines, driven by Mond producer-gas, and an arrangement was made to take current from their three-wire system, at 440 volts for the motors, and at 220 volts for lighting purposes. The present charge is 8 cts. per Board of Trade unit (K-W.-hour) for both power and light.

Wedge-Gearing.—As before stated, the superstructure when at rest across the river is kept in position by means of two pairs of wedge-blocks placed on cross-girders H and J, Fig. 1, supported by the screw piles, which also retain the fixed shore spans. These wedges are actuated by 4-B. HP. electric motors, and are pushed home from the centre line outwards; they have a rise of 1 in 1½, and when withdrawn give a clearance of 3 ins. The speed of the motors is 1,100 revolutions per minute, reduced by

gearing and screws until the total stroke of 24 ins. is made in 10 secs., Fig. 14.

Turning-Gear.—The total weight of the mass to be revolved is 303 tons, 255 tons of which is supported by water; in addition, the area of the surfaces exposed to the wind is 605 sq. ft. on each girder, and allowing 40 lbs. per sq. ft. as a maximum wind-pressure, the author concluded that to insure the bridge being under control in all conditions of weather, and turning within the limits of time allowed by the Act of Parliament, a 20-B. HP. motor should be provided. To prevent as much as possible interference from subsidence, the motor and gearing, Fig. 10, were connected with a heavy cast-iron bed-plate, and bolted down to a monolith of concrete. Instead of direct connection between the machinery and bridge, the power is transmitted by two 1½-in. wire ropes, wound opposite ways round a vertical barrel, and fixed to the circular girder F, Fig. 1. In this manner one rope pays out while the other is being wound up, and the bridge is practically under the same control as if two hydraulic rams were used. The ends of the ropes pass through clips, and can be easily adjusted for length. To obviate friction as far as possible, the weight of the vertical drum is carried on a ring of 1-in. steel balls placed between two Whitworth compressed-steel plates, and the thrust of the worm on the motor-shaft is also taken by ball thrust bearings. The benefit of these bearings is obvious, as it is possible to revolve the gearing when without load by gripping the motor-shaft in the hand, although the total weight of the gearing and armature is about 50 cwt. The actual weight of the spur-wheel drum and shaft, Fig. 10, is 31 cwt. The bridge is brought to rest by means of a check-chain, attached to the tail end and to the concrete wall in such a manner as to stop the bridge in the correct position both ways. A dial in the switch-cabin shows the actual position of the bridge, and is useful at night-time. Owing to its being necessary to have the interior of the cabin well lighted at night in order to see the ammeters, and therefore very difficult to see the exact position of the bridge, a small lamp is fixed on the tail end in such a way that the light, shinging through a vertical slit, coincides with two vertical rods when the bridge is in position, somewhat on the principle of the cross staff.

Lighting.—Each bridge is provided with a 2½-ampere Stewart arc-lamp at each end, and 16-candle-power incandescent lamps for use after midnight. The switch cabin is also lighted electrically, but is heated by ordinary gas supplied by the local gas company.

Switch Cabin.—All the switches are arranged in a wood cabin fixed over the turning-gear, and by means of numerous windows the attendant has a full view of everything, as well as full control. One of the most important points in connection with the electrical installation was the circuit-breaking, and a most ingenious arrangement of switch was devised by Messrs. Mather & Platt to prevent injury to the motors. The main idea was so to arrange the switches that nothing short of wilful neglect on the part of the attendant could cause an accident; the points to be met were briefly as follows: (a) The power must not be applied too suddenly; (b) any increase of current beyond the safe limit must be immediately checked; (c) there must be some indication when the motions, more especially of the wedges, are complete; (d) the switches must be simple in action and arrangement so that men of ordinary intelligence can manipulate and keep them in order; (e) they must reverse. The essentially novel points in connection with their construction are: (i) Automatic disconnection in case of a too sudden load or an over load. (ii) There is only one moving contact for each motion. (iii) The same set of resistance-terminals acts for both opening and closing motions of the motors.

The arrangement is shown in Fig. 11, and consists of two radial contact levers, L L', being caught up as required by the third lever, b, which has a spring catch similar in action to a railway signal-lever. This lever, b, is of course insulated from the contact levers which form part of the circuit. To open, the lever L is caught up and moved through the resistances, while L' remains in position and forms part of the circuit; to close, lever L' is moved and L left in normal position. Should either of the levers be pushed too far over, the spring-catch would release itself and the lever fall to normal. It will be easily seen that although the main motor for turning the bridge can be started slowly and stopped slowly through resistances, that is not the case with the motors driving the wedges. The wedges and their motors being under the bridge are out of sight of the attendant, and it was therefore essential for everything to be automatic; this is accomplished as follows: In the first place, the motors are allowed to start without any load by means of slots in the connecting links, but as soon as the nut of the actuating screw reaches the end of the slot, full load is bound to come on until the wedge is released, when it again falls to a minimum. On returning the wedges all is light load until the last push, but as the final position of the wedges is slightly variable owing to subsidence or temperature, it is impossible to know when to break circuit unless the ammeter is carefully watched, and even then sometimes before the man can disengage, the current has risen abnormally to perhaps 25 volts or 30 volts. The whole operation of withdrawal or return only takes 10 secs., so that prompt attention is necessary. In order to give as much warning as possible, spring buffers have been fixed, which gradually increase the resistance and warn the attendant; but should he not be in time, an automatic cut-off has been arranged so as to disengage the switch on a certain limit of current being reached. This arrangement consists, Fig. 11, of a pair of solenoid coils fitted with plungers connected to a cross-bar and spring A. The cross-bar is connected by means of a piece of flexible wire to the disengaging lever, b, and on a current of 30 amperes (about three times the normal load) passing through the circuit, the plungers are attracted and disengage the secondary radial lever, L, from the hand-lever; the counterweight, W, then causes the secondary radial lever, L, to fall through the resistances to zero. In this manner there is ample protection to the motor whether the attendant is on the alert or not. The solenoids are connected in a "shunt" circuit. In order to minimize the danger of a too sudden application of the load, it was thought well to make a substantial lever and counterweight; the attendant has, therefore, to do a slight amount of physical work, and is reminded of the forces which are being set in motion by his action.

As a rule, the gates can be closed, wedges withdrawn, and bridge turned in 1½ mins., although by the act of Parliament 1½ mins. was the time given for turning the bridge only, without the other movements. The amount of electric current used for the complete operations of opening and closing, including the wedge-motions, is one quarter of a Board of Trade unit, costing 1d. Although more power is required during a high wind for moving in one direction, less is required for the reverse direction, as the wind assists. The attendance of one man and a youth is required by day and by night.

Cost.—The cost of the undertaking was largely increased by the construction of 303 yds. of new streets, rendered necessary by the condition that two bridges should be provided. The gas and water mains crossed the old bridge, and as it was not considered safe to rely on a single siphon under the river in such treacherous ground, Parliament decreed a second pair of siphons near the site of the second bridge and their connection with existing mains by new mains along the new streets and across the River Dane (a tributary of the Weaver) to points suitable for connection with the existing pipe-lines. In the case of the gas, the new main measures 732 yds. of 8 ins. in diameter, and the new water main measures 1,227 yds. of 10 ins. diameter. The new streets are 36 ft. wide, and are well constructed with Yorkshire flag pavements, macadamized roadway, and stoneware drains; the pipe-lines are of full strength and are provided at intervals with long thimble-joints to allow for stretching, due to subsidence of the ground; all the joints of the water pipes have rings bolted on, in order to prevent the lead from being drawn out while stretching. The siphons under the river consist of welded and flanged steel tubes, jointed with rubber rings and tightly bolted together. The first cost of the bridges can scarcely be compared with that of others built on sound ground; every detail had to be designed to meet the peculiar circumstances and to prevent as far as possible any heavy maintenance costs. So far as the cost of attendance and of power for operating is concerned, this seems to have been accomplished; in the case of the adjustments only time will show; the author has, however, no doubt of the soundness of the principle adopted. Future bridges on the same principle, but erected on sound ground, could certainly be built more cheaply, but the total cost of the two described is: Navigation Bridge, including fixed spans, but exclusive of roads and pipes and foundations, £9,031; and Town Bridge, £7,904, the price of material and labor being now considerably higher than it was a few years ago. The electric machinery, etc., cost an additional £1,100 for each bridge.

The foundations, timber piling, concreting, excavations, etc., were carried out by the trustees' own men under the author's direction, but the electrical plant and iron and steel work were let by contract. The late Mr. Thomas Hawksley was joint engineer with the author in obtaining Parliamentary powers, the scheme being strongly supported by Sir Benjamin Baker. The author is also indebted to Mr. John J. Webster, M. Inst. C. E., for his suggestion of the pontoon principle and his assistance when the original designs and models were made in 1893.

Postscript.

In reply to question asked and criticisms made during the discussion of the paper the author would like to add that, since writing the paper, the Town Bridge at Northwich had been turned, up to midnight on Jan. 6, 303 times; and that, exclusive of current used for the tail gates, but inclusive of current used for trials for the wedges, 97 K-W.-hours had been consumed. The quantity now required was less than at first, and for the last 53 times had averaged 0.226 unit each time, for the complete cycle of operations mentioned in the paper.

It was thought at one time that three piles would be sufficient support at each bridge, but, of course, they would have had to be of greater area and strength. With subsidence going on, it was thought adjustment would be much easier with the larger number of piles. One pile might go a little farther than the others, and there would be a better chance of adjustment than if the bridge depended on only three piles. With regard to the floating out of the pontoons for repairs, it would be noticed that there were only seven piles, and that the eighth pile was missing. That enabled the pontoons to be floated out one at a time. There would, of course, be a difficulty in getting out the back pontoon, and the whole thing would have to be turned round before that could be done, but it was thought in such a case the bridge would have to be turned off or left across the river while the repairs were being done, and it would not be exactly workable in an extreme case as that. Provision had been made, however, for repairs. The braces in the main girders were formed, in most cases, to act either as ties or struts, the contingency of the bridge being left across the river without a center-pier being taken into consideration at the time. Before being accepted the navigation bridge was tested by means of two steam road-rollers, weighing 13 tons each, which were run side by side from one end to the other without appreciably deflecting any part of the bridge. With regard to the wedges taking the weight, there was only the 48 tons to be dealt with; the remainder was on the river, and the wedges were only driven home sufficiently to prevent the bridge from oscillating when traffic went over it. No difficulty had been experienced up to the present, and the bridge was always very steady when across the river, with the wedges home. It had already occurred that one side of the girder was found to be a little lower than the other, and the only thing necessary was to take the screw off its bearing and screw it a little bit farther into the nut, so that one wedge went home sooner than the other. That met the case exactly.

As to the power of the motor, it was desirable that it should not be too small, and in comparing it with the power of engines put down for other bridges, and bearing in mind the fact that the bridge might have to be turned in a gale of wind, he thought he was, at any rate, keeping on the right side. He was rather astonished at the very low power required to move the bridge, and the very small cost.

With regard to ball-bearings, although he was afraid they appeared from the diagram to be circular, they were in reality in a semi-V groove; in other words, the balls only bore at four points; they had not given the least trouble, and he would like to say that for the last 15 years, if not more, ball thrust-bearings had been in use on the steam-tugs on the river, and some of those bearings had worked for years without the least attention. After a certain time the steel plates wore down and perhaps some of the balls split; but some of the tugs had been working for five or six years without the least attention to the ball thrust-bearings.

With regard to subsidence in the salt district, it varied considerably in different places. It would be difficult to prophesy the exact form which it would take in any particular case, but for many years the site of the two bridges had subsided gradually in comparison with the other portions of the district, and although one side might go down a little faster than the other, there had been no tremendous pitfalls, where the ground had fallen to a depth of perhaps 20 ft. at a time, as it did in some of the cases in the neighborhood, and so far as one could tell there would not be any. The subsidence was caused in two ways; first, by the mining in the old days when the pillars were not left of sufficient size, and the mines filling with fresh water, the pillars gradually melted and let the top in suddenly; and, secondly, by the gradual extraction of the salt in the form of brine, by means of pumps. The cause of the subsidence was at least 150 ft. down, and actual strata at the surface, although consisting of sand and sand mixed with clay and gravel, subsided from the withdrawal of the support below, and not from any inherent defect in its own nature.

The reasons for not using high pressure hydraulic power for operating the bridge as in ordinary English practice were not only the placing of the weight on the ground instead of the river, but also the great cost and difficulty of maintenance of a pumping station, which with its accumulator must have been on subsiding land. The flexible pipes mentioned had not been overlooked by the author, but he considered that although in constant use they were very serviceable, yet should joints in such pipes be buried in the ground, as in this case they would have been, they would in all probability become stiff and would not act when the time for action arrived. His objection to a lifting bridge, which he also had under consideration, was chiefly that if the four pillars settled irregularly and departed from the vertical, the columns, over 55 ft. high, would have been subjected to considerable bending stresses of an uncertain nature.

As to the rate of subsidence, he had found in November, 1887—when he took charge of the river—that a mark on the worst corner of the old bridge stood at 49.54 above Ordnance datum, and this became, by more or less rapid subsistance, 47.70 in January, 1893; he had then raised it to 48.79, but by the 14th November, 1898, when the demolition was commenced, it had sunk to 47.78, or 2.85 ft. in 11 years. All the surrounding property had also subsided, so that further raising would have been intolerable. The adjacent bridge over the River Dane had subsided from 49.45 to 43.20, or 6.25 ft. between 1882 and May, 1897. The expense of removing the obstruction was, no doubt, largely increased by the erection of the second bridge with roads, etc., but it must be remembered that the risks of small failures to any form of movable bridge on this site were greater than they would be on firm ground, and also that the cost of a temporary bridge—

...must have been practically on the site of the Navi... Bridge—had been saved. As to the protection of the ...ons; they were painted with three coats of red lead ... and two of a mixture of tar, red lead and cement, ...ed hot, before being launched. The salt in the Weaver ...not exceed about 0:3% in the summer, and 0:15% in ...inter, and he had found that submerged iron and steel ... did not suffer more than in other inland waters, a ...table film forming on all submerged work, which ap...ed to protect it.

AN 80-TON ROLLER THRUST BEARING.

When rollers are used in a thrust bearing they ... usually made conical, as, theoretically, they ...ould be to run on a circular track. In the bear... illustrated herewith, however, the rollers are ...indrical, but they are made so short that the ...dency to creep or slide is immaterial. The ...llers are not journalled in the ring or cage, as ...y be seen from the drawing. These rollers will, ...f course, stand much heavier pressure and can run

Fig. 1.—80-Ton Roller Thrust Bearing Made by the Ball-Bearing Co., Boston, Mass.

at higher speed than balls, and they are much less expensive to make than conical rollers. The use of vaseline as a lubricant is advised in this type of bearings. The one shown in the half-tone view is intended to withstand a pressure of 80 tons. The one shown in the drawing was designed to carry 5½ tons. The method of securing the rollers is the same in both cases. These bearings are manufactured by the Ball-Bearing Co., of Boston, Mass., who have furnished us the above information.

DEFECTS EXPERIENCED IN BELLEVILLE BOILERS IN THE BRITISH NAVY.

So much public interest has been manifested in the reports of difficulties experienced with the Belleville water-tube boilers in the British Navy that the Admiralty has recently issued a statement as to the chief defects which have been experienced in the working of these boilers. We print this below, and may add that the question as to whether the use of these boilers shall be continued or whether some other type of boiler shall be substituted is now before an expert commission, the members of which were given in our issue of Aug. 23, p. 117.

Corrosion of the Baffle Plates in Steam Collectors.—These being made of thin plates, corrode rapidly, and the rust and scale are liable to be carried into valve seatings or other places where they may do harm, though the greater part of the scale is deposited in the mud drums. Modifications have been made in these fittings in "Terrible," "Diadem," "Furious," and "Arrogant," which it is expected will greatly reduce the amount of corrosion. New ships are being fitted similarly, and completed ships altered as opportunities offer.

Joints of Doors Leaking.—This occurred to a serious extent in the "Argonaut" during last year's manœuvres, due to the doors not being interchangeable and to unsuitable asbestos washers being used for making the joints. Since suitable washers have been provided, very little fresh trouble has arisen from this cause.

Float Gear of Automatic Feed Corroding.—Portions of these, specially liable to corrosion, have either been galvanized or bushed with bronze as opportunities occur, and there has been very little trouble with them lately.

Non-Return Valve in Down-Comers.—The pins of these became corroded in the "Terrible," and the valves failed to act, but since attention has been called to them and they have been refitted, no fresh trouble has arisen.

Supports for Back Ends of Tubes Getting Hot or Burning Away.—Such heating has happened in some cases, where they were insufficiently protected by the brickwork, or where the latter has been destroyed. For new boilers, and also in cases where old brickwork becomes defective, it is built up in an improved manner, and its behavior is then satisfactory.

Nickel Washers Leaking.—This is generally caused either by bending of the generator tubes, or the dropping of the back ends by the burning away of the supports at the back of the tubes, as above. When the supports are properly protected, and the tubes are not allowed to get overheated from imperfect circulation or shortness of water, leakage rarely occurs. In any case the washers can be very quickly duplicated or replaced.

Pitting of Tubes.—This occurred to a considerable extent in the "Diadem," thirteen tubes in all being pitted through. Methods of preventing it are under trial, namely, galvanizing the interior of the tubes, and the use of zinc rods; also more care is being taken to prevent the water from becoming acid, by the use of lime.

Leaky Safety Valves.—These are a frequent source of trouble, which is increased with the higher pressures of steam. Leaving out the greater difficulty of making tight joints at high pressures, in many ships the cause has been the cutting of the valves and seats by scale and other foreign matter blown out of the steam collector. Where this has occurred, it has been remedied by having the steam collectors thoroughly washed out and the valves refitted. With the newer machinery designs, the simplification and galvanizing of the internal baffle plates will reduce the liability of leakage due to this cause, and as opportunities offer the steam collectors of the older designs are also being galvanized and simplified. In a few cases the leaky safety valves experienced were due to defective designs which were not suited to the high pressure, and new valves were fitted.

Bursting and Overheating of Belleville Boiler Tubes.—Either bursting or overheating has occurred in the "Powerful," "Terrible," "Arrogant," "Furious," and "Hermes." In new ships, on contractor's trials, when overheating has occurred, it has been principally through obstruction to the circulation of water by some foreign matter, such as wooden plugs or waste being left in the boilers. In a few

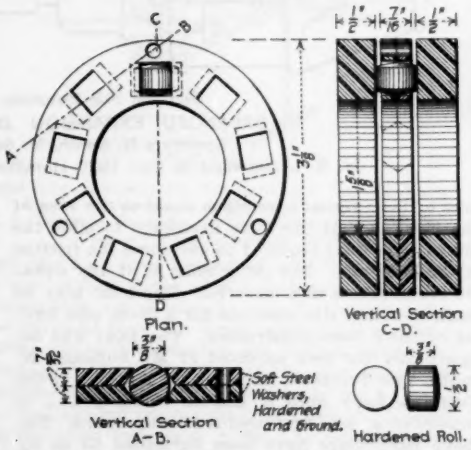


Fig. 2.—Details of Construction of 5½-Ton Roller Thrust Bearing.

cases, defects of manufacture have been the cause, especially before the manufacture of solid-drawn tubes was properly developed. This was the case in the "Powerful." In ships in commission the cause has generally been either shortness of water or the presence of saline deposits in the tubes due to the admission of sea water, while the necessary blowing off to keep down the density under these conditions was neglected. This was the case in the "Terrible." In the "Arrogant" there was a combination of these two causes. In the "Furious" only two very small splits occurred in two adjacent tubes. They were not observed until the boilers were examined after steaming. The tubes were clean, but the general appearance of the elements of which these tubes formed part showed that overheating was the cause. No doubt this boiler had been short of water. With tubes of the quality now supplied to our boilers, provided solid deposits are excluded, and the proper quantity of water is kept in the boilers, this source of trouble should be eliminated.

Salt Water Obtaining Access to Belleville Boilers.—Cases have occurred in which sea water has been used in these boilers without much inconvenience, provided proper precautions are taken; but on the return voyage of the "Terrible" from Malta with relief crews, the undesirability of allowing any access of sea water was shown. Although, as stated above, sea water can be used if care and due precautions are exercised, yet the small quantity of water contained in the boilers renders the rise of density comparatively rapid, and the danger of saline deposits correspondingly great, especially at low rates of combustion. In the "Terrible" many of the tubes were salted up and burst, or were otherwise damaged. The sea suctions of all feed pumps have now been blanked off to prevent the unauthorized use of salt water, this and leaky condensers being the usual causes of salt water getting into the boilers. Excluding "Hermes," which is an entirely exceptional case, most of the defective tubes occurred in the "Powerful," "Terrible," and "Arrogant," which were the first ships commissioned. The greater part of these occurred in the earlier part of their commissions, when the management of the boilers was less understood. Since the accident to the "Terrible" in the previous paragraph, the number of tubes damaged has been much reduced.

Boiler Tubes Being Pulled Out of Junction Boxes.—This has occurred in two ships, the makers of the boilers being the same in each case. It was due to the thread in the junction box being defective, and was a case of bad workmanship which the overseers had not detected.

Feed Collector Tubes Laminated.—In a few cases laminations have developed in these tubes, principally on the fire side. The cause was defective manufacture. Where this defect has occurred, however, it has not been such as to interfere with the steaming of the particular boiler. The laminated tubes have been removed, and new ones fitted. These feed collectors are now being largely made from solid bars bored hollow.

Smoke-Box Doors of Belleville Boilers Defective.—These doors are found sometimes to warp and buckle under the influence of excessive heat, occasionally resulting in the bolts of the doors not entering properly into their sockets. This defect, if not remedied, causes a loss of economy in combustion. The overheating is generally due to inferior stoking. In the newer ships, the smoke-box doors are being made of smaller dimensions and of a stiffer design, which will reduce the tendency to this defect.

EDUCATION OF RAILROAD MEN AS SUBORDINATES FOR THE MAINTENANCE OF WAY SERVICE.*

By Walter G. Berg, M. Am. Soc. C. E.†

I have paid particular attention for more than 20 years to the question of the proper education of railroad men, and have visited, supplied with suitable government credentials, the principal technical and trade schools of the Continent and subsequently of this country. In publications and remarks made heretofore on this subject I have enlarged and explained more fully that, in my opinion, there are three principal points to be kept distinctly in mind in discussing the question of the proper preparatory education of railroad men:

First. A clear division should be recognized, from a preparatory educational standpoint, between the higher and middle classes of railroad men and the educational systems kept distinct and separated from each other.

Second. The higher class, offering the material from which, as a rule, the future managers, professional men and heads of departments will be drawn, should be provided for by special railway departments at existing colleges and by adding general railway subjects to the present curriculum of the technical departments of colleges.

Third. The middle class of railroad employees, comprising young men entering the railroad service in subordinate positions of all kinds, many of whom will some day fill the large number of responsible minor railroad positions of trust, should receive, after leaving the ordinary school course, a special short preliminary schooling adapted to the particular departmental work they expect to take up on entering a railroad shop, gang or office. This special education will be obtained most advantageously in special railroad trade schools to be established wherever desirable and possible throughout the country.

We have in railroading, the same as in every business or industrial enterprise, three classes of men. The higher educated class leads and instructs the middle class; the latter supervises the work and carries out the infinite number of details connected with it; while the lower class performs the heavy manual work. The first class represents the experienced thinkers, organizers and leaders; the second, the supervisors and skilled assistants or workmen; the third, the common labor.

The European governments long ago recognized the necessity for a strict distinction between professions and trades or callings. They emphasize throughout their national educational schemes the fact that an institution cannot accomplish two different objects at the same time. Their classical, scientific and technical universities or colleges are such as to command the highest respect for their graduates, while their lower grade industrial or trade schools turn out men fitted for the better class labor, artisans, foremen and supervisors.

*Condensed from a paper read at the 18th annual Convention of the Eastern Maintenance of Way Association, Saratoga Springs, N. Y., Sept. 19, 1900.

†Chief Engineer, Lehigh Valley R. R., 26 Cortlandt St., N. Y. City.

It is neither unreasonable or un-American to admit frankly that there is a great middle class of railroaders that has to be considered as a separate body in any educational scheme. This admission does not mean a division of classes according to horizontal strata, as there is nothing to prevent exceptionally bright and energetic men working their way out at the top. It simply acknowledges the fact that the masses, not the exceptions, establish the general rule in dealing with any educational problem. Many parents can afford to give boys two years' extra schooling after leaving public school, whereas it would be out of the question financially, independent of any other considerations, to let the boy go through college. My contention is that we have no well-recognized system for giving these men a special adequate preparatory technical education subsequent to their leaving public school and that special railroad trade schools should be established for this purpose. These schools would be to the subordinate branches of railroad work what commercial schools or so-called business colleges are to business. They would, as a rule, be interpolated between the regular public school course and a boy's entrance into practical railroading.

The ruling tendency in this country is to place a boy after completion of the public school course in an office, shop or gang, and to trust to his industry, ability, energy, grit, and frequently luck to advance him to lucrative and responsible positions in the service. Many an example could be cited of boys who had started thus and subsequently climbed to the pinnacle of success, supplementing their early deficient training by private study or night schools. But these are exceptions, and in considering general educational problems we have to deal with the masses, not the exceptions.

Practice, in the sense of becoming skilled or expert in some particular detail of a calling or familiar with a mass of data, statistics and facts appertaining to the immediate work of one department or of a whole system of roads, can naturally only be successfully learned in practice. But, unless some stimulating influence be kept alive, or the boy's interest in his calling awakened, and his observing and reasoning faculties trained and developed prior to entering practical life, he will labor under the great disadvantage of never being able to fully grasp the general scope and duties of his calling, taken as a whole. He may become familiar with its general features by being thrown in constant contact with the subject for many long years; but experience is a very slow teacher, and usually costly to the party who pays the bills.

The natural tendency of work in a shop, office or gang to-day is to concentrate the worker's attention on the details of a single process, method or system. From my experience I have formed the conclusion that the men very seldom make use of the wonderful opportunities for observation and improvement supposed to be afforded them. The routine work confines them to one machine or one class of duties for days and months at a time, and even the entire shop or office, taken as a whole, only illustrates one particular branch of the work.

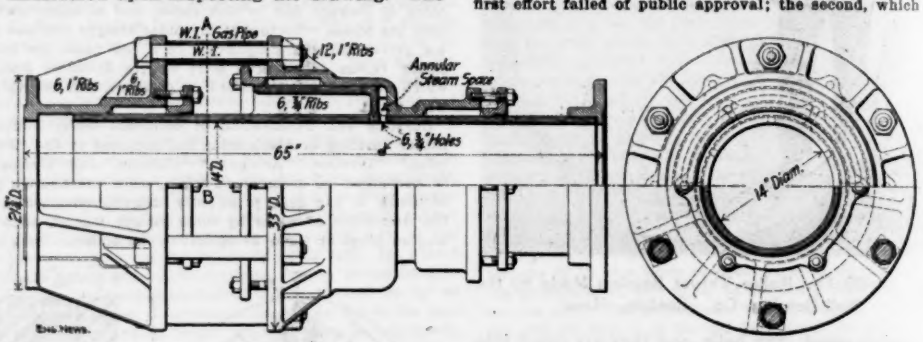
The educated employee, on the contrary, would enter his calling with a good general idea of the subject before him, and of the important principles involved, together with a knowledge of kindred subjects and familiarity with auxiliary branches. He will not be forced to work in the same channel as others before him, prescribed by usage and tradition, but will reach correct conclusions by his knowledge of principles and acquaintance with the work and results of others in the same field. In place of understanding only one branch of his calling, like the machinist assigned to one machine, or like the clerk checking off figures from morning to night, he will be better prepared, when the opportunity presents itself, to launch out and demonstrate his ability to attend to more than one detail of his business, or to supervise the work of others in the same department. Uneducated inventors have squandered years of valuable time developing and ascertaining one principle, or demonstrating to themselves the fallacy of a certain line of reasoning, which the educated mechanic understands and fully realizes at the start. A clerk will labor for months and years over his books, rate-sheets and statistical statements, and may never grasp understandingly the general principles and rules governing his work; while the specially educated clerk will be more liable, after mastering the immediate details of his work, to bring reasoning and analytical criticism to bear, devising improvements and alterations, guided by his ability to reason and think logically and his general knowledge of similar matters.

Another important element of the preparatory education will prove to be the development of the boy's faculty to study and learn from technical books and to direct his attention to the existing literature pertaining to his calling and the methods for consulting same. I do not wish to be understood for a moment as considering that a trade can be mastered by studying books. I do claim, however, that a young man after studying what literature he can relating to his calling, keeping the books within reach for reference, and further also having ascertained how to seek information from books, is far better equipped and valuable to his employers than the man who knows only vaguely that information on certain subjects can be found in books and does not even then understand how to utilize them. Take track-work, for instance; it would be certainly presumptuous to claim nothing of value could be learned from books like "Railway Track and Trackwork," "Trackman's Helper," "Roadmaster's Assistant," "Maintenance of Way Standards," "Practical Switch Work," "Standard Turnouts," etc. Similarly, books could be mentioned for other lines of maintenance of way work, all written in a popular style, and hence well adapted for the class of men under discussion.

It does not seem preposterous to suggest that every important railroad center should have a large, well-equipped railroad trade school, for the education of the better class of railroad employees and artisans, with a view to giving them a training consistent with their elementary schooling and the means at their command, thus enabling them to enter and follow practical railroading with a broader and more general knowledge of the subjects before them, unhampered with total ignorance of its first principles, and yet not burdened with too much learning and unnecessary theory. One important feature, however, should be kept prominently in view, namely, never mind what the inducements might be to devote energy and time to the higher theoretical and professional general branches of railroading, the first aim of the school should be to educate the better class of railroad labor, artisans, foremen and supervisors, giving them a special preliminary general training for the immediate practical duties before them.

A BALANCED EXPANSION STEAM-PIPE JOINT.

An ordinary sliding or expansion joint in a pipe containing a fluid under pressure is constantly acted upon by a force tending to drive the two sections of the pipe apart. This is apt to give rise to creeping, and to cause great strain on the flanges, fittings, etc. The device shown in the accompanying cut is a balanced joint in which this difficulty is overcome. The fluid under pressure is admitted to an annular space surrounding the pipe, as shown, where it acts to force the two parts of the pipe together, in a manner that will be easily understood upon inspecting the drawing. The area of the annular opening is equal to the area of the pipe, so that the force necessary to slide the joint is only that required to overcome the friction of the packings. The latter may be of any suitable construction and material. The joint may be made to fit any size pipe, one for a 20-in. pipe having recently been constructed. The joint was designed and has been patented by Mr. Sommers N. Smith, Vice-President and General Manager of the Neafie & Levy Ship & Engine Building Co., of Philadelphia, who first used it on ship-board. The above particulars have been furnished to us by the manufacturers of the joint, Messrs. H. B. Underwood & Co., 1025 Hamilton St., Philadelphia, Pa.



Sectional Side Elevation. Sectional End Elevation.

BALANCED EXPANSION JOINT FOR STEAM PIPES.
Sommers N. Smith, M. Soc. Naval Engrs., Designer.
H. B. Underwood & Co., 1025 Hamilton St., Philadelphia, Pa., Manufacturers.

A YEAR'S MUNICIPAL DEVELOPMENT.*

By Clinton Rogers Woodruff.†

The Proceedings of the first Conference for Good City Government, published in 1894, contained a bibliography of the literature of municipal government and its betterment. 39 pages sufficed for this purpose. The first number of "Municipal Affairs," published in March, 1897, contained a similar bibliography, which required 224 pages. A new edition is in process of preparation and its editor advises me that upwards of 500 pages will be required to accommodate the references.

The Philadelphia Proceedings also contained a brief account of the then existing municipal reform organizations in the county. Forty-five were described. This year the National Municipal League has 119 organizations on its roll of affiliated members and its records show a grand total of 463 devoting all or a part of their time to the study of the municipal problem.

These figures tell their own story. They tell directly and forcibly the phenomenal growth of interest in municipal affairs within the past decade.

In three states charter reform has occupied a prominent and conspicuous place during the past two years. California, Minnesota and Wisconsin easily occupy the first place in this matter. San Francisco's new charter went into effect January 1, 1900, under the auspices of a administration that had been largely responsible for its adoption and was friendly to its proper enforcement. The results thus far have been satisfactory to the friends of municipal reform, including the Merchants' Association of the city which, with Mayor Phelan, shares the responsibility and credit for its adoption and inauguration.

The experience of San Francisco has been such as to encourage other California cities to take steps to secure newer and more modern charters. Under the constitution and the laws of the state a board of freeholders, 15 in number, can be appointed charged with the duty of drafting a charter, submitting it first to the voters and then to the legislature. This system constitutes an imperfect system of home rule. The people can protect themselves against the enactment of an inadequate or pernicious charter, but they cannot make sure of having their affirmative desires carried out.

The San Francisco charter, while hardly entitled to be classed as a model, is an advanced piece of work and represents careful thought and study of the situation and an intelligent comprehension of the problems confronting modern cities. Its influence has been for good and the movement for improved charters in California has been materially helped and strengthened by its example.

In Minnesota a recently adopted constitutional amendment permits the framing of home rule charters. Under this and the enabling acts passed by the legislature, the local courts are authorized to appoint upon petition a commission to draft and submit a charter at a special election. A four-sevenths vote is necessary for adoption. Minneapolis has twice availed itself of this opportunity. The first effort failed of public approval; the second, which is regarded as a much better instrument, will be submitted to the voters in November. St. Paul has adopted a new charter which, while it represents an improvement, is signally defective in that it contains no civil service provisions. The reform bodies of the city supported it, however, with great vigor because of the other substantial and important changes which it did contain. Duluth has also adopted a new charter and numerous other cities in the state are considering the question.

In Iowa, the late legislature authorized the appointment of a municipal code commission. In Wilmington, Del., the Board of Trade has continued without abatement its efforts for a new charter. The city solicitors of the Pennsylvania third-class cities are at work on a new act to improve the present system in vogue among them. In Spokane, Wash., a movement for a new charter is contemplated. Mobile, Ala., has succeeded in securing a new one.

The past year has witnessed the practical application of a new charter in Baltimore. This has been attended by a considerable reduction in the rate of taxation (from $2 to $1.67 per $100 of assessed value) and by the reorganization of nearly all branches of the city government. In the fire department, the police force and the public schools the merit system has been, to a greater or less extent, introduced. Non-partisan boards have been placed in charge of the schools, charities and some other branches of the municipal administration and a very commendable spirit of economy has been shown by the city council and board of estimates.

In Greater New York a charter commission, appointed by Governor Roosevelt, is at work devising ways and means to correct the defects and evils of the charter of 1897. That instrument was necessarily somewhat of an experiment along certain lines, and only a few years have been needed to develop its weak points.

Many of the principles of the "municipal program" formulated by this society were incorporated in the report of the Ohio Municipal Code Commission; but as that bod

*From a paper read at the Milwaukee meeting of the National Municipal League, Sept. 19.
†Secretary National Municipal League, Philadelphia.

sought to introduce too many new ideas without the requisite antecedent preparation of public opinion, its report was rejected by the Ohio Senate. The reforms for which it stands, however, are bound to be adopted sooner or later; but the public mind must be prepared for them and the public habits conformed to them gradually. Too frequent charter commissions and reform administrations undertake to introduce too many innovations and the public receptivity for changes is quickly exhausted. Protracted discussion and agitation must precede the adoption of concrete advanced reforms, otherwise there is a great danger of a serious reaction.

There has been no abatement of public interest in the subject of the municipal ownership of municipal monopolies. Indeed, there seems to be a general acquiescence in the contention that each city should own all its franchises; although there is still a great diversity of opinion as to whether the city should control or operate them. There are few, indeed, who are willing to maintain that a city should give away or sell for all time the right to run street railways, to furnish heat, light, water, or other municipal necessities. To advocate such a policy would be to sanction the utilization of city property for the benefit of the few at the expense of the many. There are few who are willing to do this, so that the discussion has practically narrowed itself down to the determination whether the city shall merely control the franchise in a general way, reserving a fair rental, or whether it shall actually operate the plants directly. In considering this phase we find that the concensus of opinion seems to be in favor of the operation of water plants and the control of street railway operations, with opinion about equally divided on the subject of lighting. One thing is perfectly sure, and that is, as a result of all this discussion concerning municipal ownership, control and operation, there has been a material improvement in the conditions which the city has been able to impose; and secondly the people have been interested as nothing else has succeeded in doing, in questions of local government. Matters pertaining to water, heat, light and transportation come home directly to the average citizen and any policy affecting them appeals to him as no others do.

A strike like that which recently convulsed St. Louis also serves to awaken the people to the dangers incident to the private control and operation of important municipal functions. For, suffer as we may from municipal corruption and inefficiency, they seldom, if ever, reach a point where violence and bloodshed follow. Furthermore voters are coming to realize that the existence of rich corporations in a community dependent upon or seeking municipal favors and discharging municipal functions form a serious menace. Who that does not recognize the serious import of the Ramapo Water Co.'s alliance with a nefarious political combination? The united efforts of a courageous governor and a fearless controller and public spirited organizations like the Merchants' Association have been needed to check its aggressive efforts.

When was the good name of Philadelphia more seriously endangered than during the successful attempts to pass the gas ordinance and the Keystone Telephone ordinance and the unsuccessful attempt to pass the notorious Schuylkill Valley water ordinance? Out of the Keystone telephone ordinance has grown one of the gravest scandals of recent years.

The cry for municipal ownership in the abstract has often been made the cloak to hide some corrupt and selfish ends. By this I mean very often a city administration has advocated the policy of public ownership while following out ulterior purposes of public plunder. This may be taken as an illustration of the popularity of the policy or of the difficulty of establishing more than a very few reforms at a time.

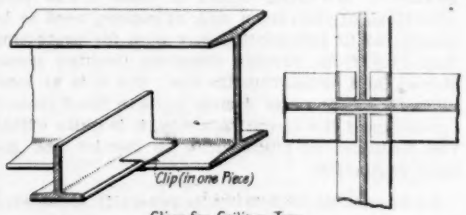
It is simply out of the question to mention the places where municipal ownership, control and operation have been discussed or partly inaugurated. The list includes nearly every state and practically every city of importance. In many localities the successful operation of the water and gas supply by the municipality "can well be designated as the most notable municipal event of the year." For instance, Duluth, Minn., feels a just pride in the success of its water and gas plants, which were acquired a few years ago after a long struggle and then placed in the hands of a competent engineer who was to be subject to no political clique or influence. "Not the faintest inclination has been shown to use the department or myself," writes the manager, "for political purposes. And therein lies the secret of our success." Rates have been reduced, the service has been made pleasant and agreeable to consumers, special privileges have been abolished, interest on the investment has been paid and a surplus accumulated. If this can be done in Duluth; if honesty, economy and intelligence can be introduced there, why is it not equally feasible to do the same elsewhere? It is, and if a story of honest business conduct of every day affairs could secure readers, a long one could be made out, but people much prefer to hear a tale of shortcoming and consequently we hear of more of the failures of municipal control and operation than we do of the successes. Naturally we conclude that the former are the rule; the latter, the exceptions. We might as well conclude that vice and immorality are the rule because the average newspaper devotes more space to them than it does to virtue and honesty. Yet we know from our own experience that the reverse is true.

Boards of trades and similar commercial bodies have likewise been enlisted in the cause of municipal improvement and the creation of sound public sentiment. As a rule somewhat more timid than organizations which devote their whole energies to reform work, they can reach and influence a class in the community which is inaccessible to all other agencies. The records of bodies like the Merchants' Association of New York in connection with the fight of the Ramapo job; of the Commercial Club of Indianapolis and its successful work for a new charter for that city, and of the Merchants' Association of San Francisco with its municipal program, to which we have already alluded, form a substantial contribution to the work for municipal betterment. The Pittsburg Chamber of Commerce and the Scranton Board of Trade have taken the leadership in their respective communities in forming auxiliary committees to promote the cause of ballot reform.

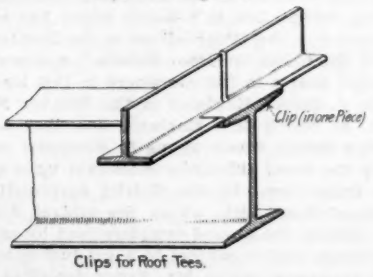
An increasing number of such bodies have made municipal reform in some one of its branches at least a feature of their work, and many, I think, show a growing desire to co-operate with other bodies in fighting corruption and inefficiency and in establishing higher municipal standards. The number of boards and chambers admitted to affiliation with the National Municipal League shows a steady increase.

STEEL CLIPS IN STEEL FRAME BUILDING CONSTRUCTION.

In connecting up certain parts of iron and steel structural work, the time and expense of drilling and bolting or riveting are out of proportion to the importance of the connections. In many structures of the steel skeleton type, special forms of steel clips are therefore used for connections where strength and stiffness are not essential. These not only reduce the time and expense required, but



Clips for Ceiling Tees.



Clips for Roof Tees.

Steel Clip Connections for Roof and Ceiling Tees, U. S. Government Building, Norfolk, Va.
H. A. Streeter, Inventor of Clip; Carnegie Steel Co., Contractor for Structural Work.

also afford an easy method of adjusting the bars to any desired width of tile sheathing. The accompanying cut shows the use of these clips by the Carnegie Steel Co. for attaching the roof and ceiling tee bars to the top and bottom flanges of I-beams in the U. S. custom house and post-office building at Norfolk, Va. The clips, it will be seen, are bent around the flanges of the tees and beams. Similar clips were used in the Carnegie Building at Pittsburg, and have also been used by the Kenwood Bridge Co. in a number of steep and complicated roofs, where it would have been practically impossible to punch holes in the rafters to receive the purlins. In the Cook County jail (Chicago), for instance, all the purlins for tile roofing were fastened by clips to the rafters (some of which were at an angle of nearly 60°), and there was no loosening or sliding of the connections.

The clips are made in an almost endless variety of forms, for connecting members of different shapes in different ways. They are made from sheets of Nos. 12, 14 and 16 gage (0.0808, 0.0641 and 0.0508-in. thick), and ¼-in. to 4 ins. wide, as required. They are the invention of Mr. H. A. Streeter, proprietor of the Globe Iron Works, 35 Indiana St., Chicago, Ill.

NOTES FROM THE ENGINEERING SCHOOLS.

Lowell Textile School.—The Massachusetts Legislature at its last session appropriated $35,000 for the textile school at Lowell, on condition that a like amount should be otherwise raised. Mr. Frederick F. Ayer, of Lowell, has now offered to furnish the required sum.

Purdue University.—The attendance this year will exceed 1,000. Preparations have made during the Summer in anticipation of a large attendance. The laboratory equipments in many departments have been increased, and one-half of the large building hitherto known as the "Men's Dormitory" has been remodeled to supply a dozen additional recitation rooms.

University of Michigan.—The course of instruction in naval architecture, which is arranged as a graduate course, will commence with the second semester of the Senior year and extend to the end of the fifth year. At the end of the Senior year students may receive the degree of Bachelor of Science in Engineering, and at the end of the fifth year, that of Master of Science. For this year only, a special course has been arranged which will extend from the commencement of the coming semester to the end of June. In the future the course will be that above specified.

POPULATION OF PRINCIPAL CITIES OF THE UNITED STATES.

The census authorities have now given out returns of the populations of a considerable number of the principal cities. We print the table as follows, including in it the ten cities for which figures were given in our issue of Aug. 23:

	1900.	1890.	Increase.	Per Cent.
New York	3,437,202	2,492,591	944,611	37.90
Chicago	1,698,575	1,099,850	598,725	54.43
Philadelphia	1,293,697	1,046,964	246,733	23.57
St. Louis	575,238	451,770	123,468	27.33
Boston	560,892	448,477	112,415	25.06
Baltimore	508,957	434,439	74,518	17.15
Cleveland	381,768	261,353	120,415	46.07
Buffalo	352,219	255,664	96,555	37.77
San Francisco	342,782	298,997	43,785	14.51
Cincinnati	325,902	296,908	28,994	9.77
Pittsburg	321,616	238,617	82,999	34.78
New Orleans	287,104	242,039	45,065	18.62
Detroit	285,704	205,876	79,828	38.77
Milwaukee	285,315	204,468	80,847	39.53
†Dis. of Columbia.	278,718	230,392	48,326	20.98
Newark	246,070	181,830	62,240	35.33
Jersey City	206,433	163,003	43,430	26.64
Louisville	204,731	161,129	43,602	27.06
Minneapolis	202,718	164,738	37,780	23.05
Providence	175,597	132,146	43,451	23.88
Indianapolis	169,164	105,436	63,728	60.44
Kansas City, Mo.	163,752	132,716	31,036	23.39
St. Paul	163,632	133,156	30,476	22.89
Rochester	162,435	133,896	28,539	21.31
Denver	133,859	106,713	27,146	25.44
Toledo	131,822	81,434	50,388	61.88
Allegheny	129,896	105,287	24,609	23.37
Columbus	125,560	88,150	37,410	42.44
Syracuse, N. Y.	108,374	88,143	20,231	22.95
Fall River	104,863	74,398	30,465	40.85
Omaha	102,555	140,452	*37,897	*26.98
Scranton, Pa.	102,026	75,215	26,811	35.65
Albany	94,151	94,923	*772	*.81
Cambridge	91,886	70,028	21,858	31.21
Portland, Ore.	90,426	46,385	44,041	94.95
Atlanta, Ga	89,872	65,533	24,339	37.14
Grand Rapids	87,565	60,278	27,287	45.27
Dayton	85,333	61,220	24,113	39.39
Richmond, Va.	85,050	81,388	3,652	4.50
Nashville, Tenn.	80,865	76,158	4,697	6.17
Hartford, Conn.	79,850	53,230	26,620	50.01
Reading, Pa.	78,061	58,661	20,300	34.61
Camden	75,935	58,313	17,622	30.22
Trenton, N. J.	73,307	57,458	18,849	27.58
Bridgeport, Conn.	70,996	48,866	22,130	45.29
Oakland, Cal.	66,960	48,682	18,278	37.55
New Bedford	64,442	40,733	21,709	53.30
Hoboken	59,364	43,648	15,716	36.02
Manchester, N. H.	56,987	44,128	12,861	29.15
Peoria, Ill.	56,100	41,024	15,076	36.75
Charleston, S. C.	55,807	54,955	852	1.55
Salt Lake City	53,531	44,834	8,688	19.37
Kansas City, Kan.	51,418	38,318	13,102	34.19
Portland, Me.	50,145	36,425	13,720	37.67
Yonkers, N. Y.	47,931	32,033	15,898	49.63
Holyoke	45,712	35,637	11,075	25.27
Ft. Wayne, Ind.	45,115	35,393	9,722	27.47
Youngstown	44,885	33,220	11,665	35.11
Covington, Ky.	42,938	37,371	5,567	14.9
Akron, Ohio	42,728	27,601	15,127	54.81
Lancaster, Pa.	41,459	32,011	9,448	29.51
Lincoln, Neb	40,169	55,154	*14,985	*27.17
Pawtucket, R. I.	39,231	27,633	11,598	41.7
Altoona, Pa.	38,973	30,337	8,636	28.47
Mobile, Ala.	38,469	31,076	7,393	23.79
Birmingham, Ala.	38,415	26,178	12,237	46.75
Little Rock	38,307	25,874	12,433	48.05
Galveston, Tex.	37,789	29,084	8,705	29.93
Elmira, N. Y.	35,672	30,893	4,779	15.47
Davenport, Ia.	35,254	26,872	8,382	31.19
McKeesport, Pa.	34,227	20,741	13,486	65.02
York, Pa.	33,654	20,793	12,861	61.85
Newton, Mass.	33,587	24,379	9,208	37.77
Sioux City, Ia.	33,111	37,806	*4,695	*12.42
Bayonne, N. J.	32,722	19,033	13,689	71.92
Montgomery, Ala.	30,346	21,883	8,463	38.67
Canton, Ohio	30,667	26,189	4,478	17.10
Butte, Mont.	30,470	10,723	19,737	189.16
Racine, Wis.	29,102	21,014	8,088	38.49
East St. Louis, Ill.	29,655	15,169	14,486	95.50
Sacramento, Cal.	29,282	26,386	2,896	10.98
Pueblo, Colo.	28,157	24,558	3,599	14.56
Atlantic City	27,838	13,055	14,783	113.24
Cedar Rapids	25,656	18,020	7,636	42.38

*Decrease. †Including Washington.

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With the success of the relief operations at Galveston, and the supply of the immediate necessities of those who survived the calamity that befel the city on Sept. 8, the question is brought forward as to whether the city is to be rebuilt, and if so what measures can be taken to protect it from similar destructive storms in the future. The growth and commercial importance of Galveston are due, we need hardly say, to the fact that it possesses the only deep water harbor on the Texas coast. The question whether other Texas ports might not be improved to furnish equal facilities with Galveston has been thoroughly threshed over during the past two decades. The unanimous report of a board of U. S. Engineers, some years ago, favoring the concentration at Galveston of the Government's expenditure on the Texas coast, may be taken as permanently settling that matter. The Government has invested about 8½ million dollars at Galveston to secure a depth of 26 ft. of water over the bar, and its results are shown in the large commerce that has been attracted there, amounting last year to about $100,000,000. These commercial facilities are an established fact. No other Texas port can accommodate vessels of any such depth, and none could be improved to afford such a depth except by large expenditures spread over several years. The talk of the abandonment of Galveston, therefore, appears idle. The surviving property-owners there are sure to exert every effort to rehabilitate their city; and the stream of commerce will certainly flow through it as soon as wharves can be repaired and railways leading to the city are restored.

It is well worth consideration, however, whether some means cannot be taken to protect the city, or at least the most valuable business and residence portion of it, from a repetition of the recent disaster. That such furious storms are likely at any time to occur on the Gulf coast, experience amply shows. The destruction of Last Island, a pleasure resort near New Orleans many years ago, and the storm that devastated the coast of Louisiana, Mississippi and Alabama in 1893, are notable examples of the danger which threatens every one of the low-lying towns and cities along the Gulf.

The most promising proposal that has been made for the protection of Galveston appears to be the suggestion that the general level of the city, or of some part of it, should be raised to a level above that attained by the waters in the recent storm. Such a work need be by no means prohibitory in expense, provided it were done on a new site, as yet unbuilt upon. To illustrate this: an acre of land contains 4,840 sq. yds. To raise sand from water of moderate depth by hydraulic dredges and discharge it through a pipe line delivering on shore can be accomplished for from 3 cts. to 15 cts. per cu. yd. Taking 10 cts. a cubic yard as a fair figure, we find the expenditure to deposit a depth of 10 ft. of sand on an acre as only $1,613. The water was from 4 ft. to 10 ft. deep in Galveston when the storm was at its height. If the general level of the city were raised 10 ft., therefore, all that part so raised would be secure against the dangers of the high tide which accompanies these great Gulf storms. At this rate, the expenditure to deposit 10-ft. depths of fill over a square mile would be only a little over a million dollars.

These figures indicate very clearly the possibilities in the way of the reclamation and protection of low-lying tracts of land. The local conditions at Galveston will, of course, need to be considered in formulating any plan for protecting that city from further disasters through ocean storms, and estimating its cost; but it is at least plain that if the city desires to save itself from a repetition of the recent calamity, it is quite within the resources of engineering to furnish the desired protection.

An unyielding foundation is generally considered a prime essential to the successful operation of a swing bridge; but in a paper which has recently appeared in the "Proceedings of the Institution of Civil Engineers of Great Britain," and which we reprint nearly in full elsewhere in this issue, Mr. John A. Saner, Engineer of the Weaver Navigation, at Northwich, England, describes a swing bridge design which seems to overcome successfully the usual difficulties attendant upon a yielding foundation. In the district surrounding the town of Northwich, where the bridges described are located, the ground is undermined by salt mine workings, and is subject to a gradual subsidence due to causes which Mr. Saner describes in his paper. At the locality of the bridge this subsidence has averaged for a long period about 4½ ins. each year. It is plainly evident that, under these conditions, a swing bridge with the usual pivot pier construction would endure a material decrease in its clear headway above the water level after a few years, even if more serious troubles were not encountered. In the two swing bridges at Northwich, Mr. Saner decided to meet the problem of subsidence by doing away entirely with a masonry pivot pier and substituting in place of it to support the swing span a circular steel pontoon floating in the water. To steady the bridge, or to keep the pontoon upon an even keel, if we may properly so term it, and to maintain the turning point or pivot of the span in a constant position, a circular roller girder carried by screw piles sunk at intervals around the pontoon chamber is provided. As this girder will, of course, settle with the screw piles as the ground subsides, the piles were provided at their tops with an arrangement by which their length is increased as the ground settles. The whole arrangement is a very simple one, and so far as the evidence now at hand goes, seems to be a very successful one for the purpose intended. Instances will occur in the practice of many bridge engineers where the conditions of securing a stable pivot pier foundation are very onerous, and it will repay them to make a mental note for future use of the structure described.

In reference to some of the minor details of the Northwich bridges, it will be noted that an unusually extensive use has been made of ball bearings, they being used not only at various points in the turning and end locking machinery, but also to reduce friction in operating the gates. Mr. Saner also calls particular attention in his paper to the fact that in these bridges electric power has been adopted for the first time in England for operating a swing bridge, and much of information which will strike American bridge engineers who are familiar with its frequent use in this country as rather curious. One feature of the masonry work done in connection with the pontoon pit and abutment construction, which, so far as we know, is a novel one, is the use of chains embedded in the concrete to give the masonry lateral strength. One more point which is deserving of mention in this country, where so little attention is usually paid to the matter, is the precaution taken to reduce noise by placing a layer of felt between the floor planking of the bridge and the steel trough flooring upon which it rests.

The recent launching of a six-masted sailing vessel from a Maine shipyard calls attention anew to the fact that steam has by no means banished sails from the ocean. Notwithstanding the recent great increase in the size of freight steamers and the vast improvement in the economy of marine engines that has taken place during the last two decades, the sailing vessel still holds its place on many routes and in many lines of trade.

More than this: it seems not at all improbable that the near future may see an increase in sailing vessels as compared with steam for ocean traffic, on account of the notable increase in the price of coal in Europe. Doubtless there will be a temporary decline of longer or shorter duration from the present high prices; but in the long run a materially higher scale of prices than has prevailed in the past may certainly be expected. It is not that the coal measures of Europe are near exhaustion; but they are all the time reaching greater depths and becoming more expensive to work, while thinner seams and less productive beds are now worked than were formerly considered profitable.

But higher-priced coal in Europe means an increased expense for every steam vessel sailing to or from European ports, and since European coal supplies the coasting stations all over Asia and Africa, it means an increased expense to practically all ocean-going steam vessels.

One probable outcome of the situation will be a return to a type of vessel which was common enough in the early days of steam navigation—the sailing ship with auxiliary steam power. It need add very little to the cost of a large sailing vessel to fit her with a small engine capable of giving her a speed of 3 to 5 knots per hour in a calm, and the coal consumption and cost for attendance of so small an engine would be trifling. Such a steam power equipment would enable a vessel to work her way in and out of harbors with little or no expense for tugs; to keep moving, even though at slow speed during calms, and to furnish its own power for handling cargo. Its advantage in securing the safety of a vessel and decreasing the risks of navigation would be enormous. During severe storms or in proximity to a lee shore, the added control of the vessel given by the steam power might often save her from shipwreck; and the advantage of steam power for pumping and for sounding fog signals are likewise of great importance.

It is even probable that such a vessel would be safer and could command a lower rate of insurance than the ordinary freight steamer relying entirely on her engines. The mortality among vessels of this class during the past few years has been astonishingly high. Breakages of screw shafts and disablement of propelling machinery by various causes have become so frequent as to raise rates of insurance, and cause alarm among shipowners and inquiry as to what changes in hull and engine construction can be devised to remedy the trouble.

Such a sailing vessel with auxiliary steam power as is suggested above would appear particularly suitable to the coal export trade from the United States to Europe, which now promises to become so important. If we can carry coal over seas

...aply enough, there is hardly a limit to the ...ume of traffic which can be built up. The cost ...carriage, however, must be kept down to the ...west point, and for such long voyages as would ... required for most of this traffic, sail power ...uld certainly appear to be cheaper than steam.

...A radical change from the present method of ...king nominations for officers in the American ...ciety of Civil Engineers is now before the mem...rs of the Society for acception or rejection. ...hile the present system is certainly cumbrous ...d open to serious objections, a well-known ...mber of the Society, in our correspondence col...mn, presents some strong reasons why the pro...sed new plan might give rise to still greater ...oubles in practical operation. Careful study of ...e proposed amendments prior to voting on the ...atter is certainly advisable.

PIG IRON PRODUCTION, PRICES AND PROSPECTS.

Now that the great boom of the iron and steel ...rade of 1899-1900 has passed, and the industry ...as returned to somewhere near a normal condi...tion, it is worth while to put on record some ...statistics of the boom period and to consider some ...of its peculiar figures. In the accompanying table

Date.	Furnaces in blast.	Capacity per week in gross tons.	Average monthly price Bessemer pig at Pittsburg.
June 1, 1897	146	168,380	$9.55
July 1, "	145	164,064	9.25
Aug. 1, "	152	165,378	9.35
Sept. 1, "	161	185,506	10.10
Oct. 1, "	171	200,128	10.45
Nov. 1, "	183	213,159	10.25
Dec. 1, "	191	226,024	10.00
Jan. 1, 1898	188	226,608	9.90
Feb. 1, "	184	228,338	10.05
March 1, "	193	234,430	10.40
April 1, "	194	233,339	10.40
May 1, "	194	234,163	10.30
June 1, "	190	225,398	10.35
July 1, "	185	216,311	10.25
Aug. 1, "	187	206,777	10.35
Sept. 1, "	186	213,043	10.80
Oct. 1, "	192	215,635	10.35
Nov. 1, "	196	228,935	10.15
Dec. 1, "	195	235,528	10.60
Jan. 1, 1899	200	243,516	10.90
Feb. 1, "	195	237,639	11.60
March 1, "	192	228,195	14.60
April 1, "	205	245,746	15.00
May 1, "	217	250,095	16.20
June 1, "	220	254,062	18.50
July 1, "	237	293,363	20.60
Aug. 1, "	244	267,672	21.70
Sept. 1, "	257	267,335	23.30
Oct. 1, "	265	278,650	24.18
Nov. 1, "	277	288,522	24.78
Dec. 1, "	283	296,959	24.90
Jan. 1, 1900	280	294,186	24.90
Feb. 1, "	296	298,014	24.80
March 1, "	293	292,643	24.90
April 1, "	291	289,482	24.70
May 1, "	292	293,850	nominal
June 1, "	293	296,376	19.75
July 1, "	284	283,413	16.75
Aug. 1, "	240	244,426	15.50
Sept. 1, "	228	223,551	14.00

we give the figures, taken from reports in the "Iron Age," of the weekly production of pig iron, of the number of furnaces in blast at the beginning of each month, and of the average monthly price of Bessemer pig iron at Pittsburg, all from June, 1897, the period when prices had reached the lowest figures ever recorded, up to the present month. The long depression of the trade which began in 1893 reached its lowest point, as far as prices are concerned, in July, 1897, although the lowest rate of production during the depression was a year earlier. By September, 1897, the depression was at an end, production increased rapidly to over 200,000 tons per week, and prices advanced slightly above the $10 point. During the whole of 1898 prices remained nearly constant, ranging from $9.90 to $10.80 per ton, and the weekly production fluctuated between 206,000 and 235,000 tons. Signs of the coming boom were noticed in January, 1899, when prices advanced from $10.60 to $10.90, while at the same time the production increased from 235,000 to 243,000 tons per week. During the next ten months prices advanced steadily until the highest figure, $25.50 per ton, was touched in November, the average price for that month being $24.78. Then for the next six months the most remarkable record in the history of the trade was made. During that long period the price of pig iron remained practically constant at $24.90 per ton, or nearly 150% above the normal price of iron in the year of good business, 1898. New records of production were made under the stimulus of advancing prices, and for nine months, November, 1898, to July, 1899, inclusive, the weekly production ranged above 280,000 tons. The end of the boom came in May, 1899, when prices were recorded as nominal, as purchasers refused to buy at quoted figures, and each month thereafter has shown a steady fall in price, down to $14, the figure now quoted. The production, however, kept above 280,000 tons per week until July 1 last; but in the next two months it fell rapidly to 223,000 tons, the lowest figure since Oct. 1, 1898.

The accompanying diagram, Fig. 1, plotted from the table, shows the progress of the boom more clearly than do the figures themselves.

We have added to the diagram a curve showing the stocks of pig iron, sold and unsold, at the furnaces at the first of each month, beginning July 1, 1899. The relation of the amount of stock on hand to the selling price per ton is evident. In ordinary times a stock of half a million tons is not unusual, and it would seem to be small enough, since it is only equal to about two weeks' produc-

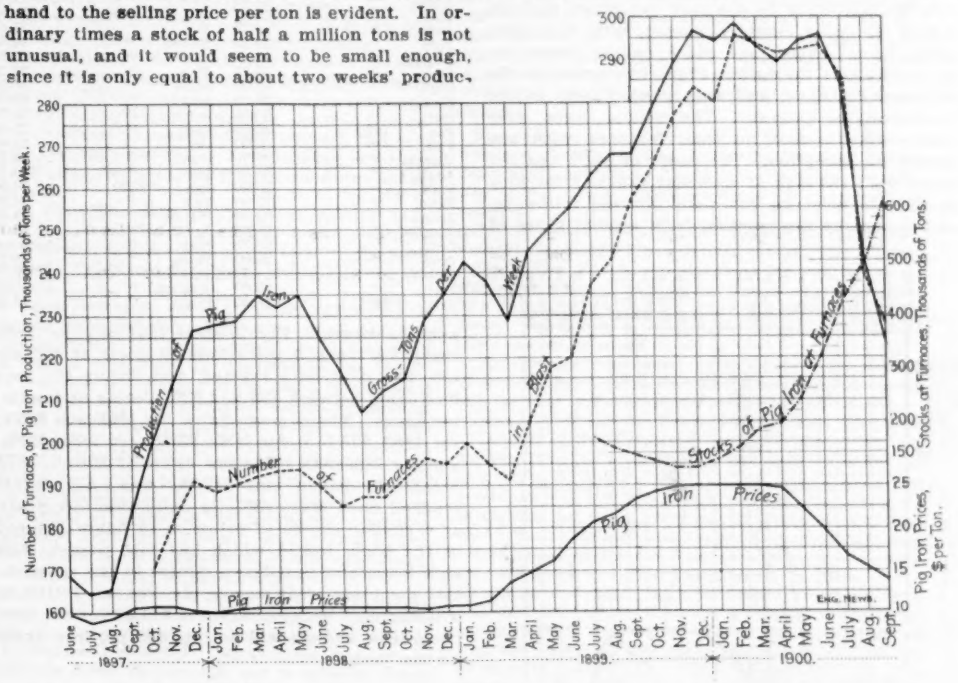

Number of Furnaces, or Pig Iron Production, Thousands of Tons per Week.
Stocks of Furnaces, Thousands of Tons.
Pig Iron Prices, $ per Ton.
Production of Pig Iron, Gross Tons per Week
Number of Furnaces in Blast
Stocks of Pig Iron at Furnaces
Pig Iron Prices
1897
1898
1899
1900

FIG. 1.—PIG IRON PRODUCTION AND PRICES, JUNE, 1897, TO SEPTEMBER, 1900.

tion. The rise in price up to the highest figure, in November, 1899, was coincident with a shrinkage of stocks to 111,543 tons, or only a little over two days' production, probably the closest approach to an actual famine in pig iron that has ever been known. The figures of stocks on hand, according to the "Iron Age" reports, are as follows:

July 1, 1899	169,335	Mar. 1, 1900	185,152
Aug. 1, "	150,268	April 1, "	197,532
Sept. 1, "	137,821	May 1, "	241,077
Oct. 1, "	120,541	June 1, "	334,680
Nov. 1, "	111,543	July 1, "	421,038
Dec. 1, "	113,193	Aug. 1, "	504,341
Jan. 1, 1900	127,346	Sept. 1, "	594,218
Feb. 1, "	148,336		

The stocks have now returned to the normal state of an equivalent of two weeks' production, and all fears of scarcity of pig iron have disappeared.

In our issue of Oct. 16, 1899, a month before prices had reached their highest point, we had occasion to discuss the condition and prospects of the iron and steel trade as they appeared at that time. The following quotations from that article may be of interest now in view of what has since taken place:

As to reserve capacity of furnaces, which may be relied on to meet the continually increasing demand, and to check the advance in prices, there is almost none. The furnaces now in blast are undoubtedly being driven to the utmost capacity, of which their blowing engines and steam boilers are capable. * * * If all the furnaces now out of blast could be put in blast, they would add only about 16% to the present rate of production. But this is not possible, for there are always some furnaces out of repair, others are dilapidated and practically abandoned, and if capital could be secured to repair and run them they could not be put in blast until the period of high prices will probably have passed.

That the reserve capacity had almost been exhausted at that date is shown by the fact that notwithstanding the stimulus of advancing prices and increasing demand, the highest weekly rate of production, 298,014 tons, reached four months later, was less than 7% above that of Oct. 1.

As to the prospects of the trade at that date, we said:

The present position of the pig-iron producer is, therefore, one of extraordinary strength, and almost every feature in the situation seems to offer the prospect either of the maintenance of the present high prices for several months to come, or of their still further advance.

Both the advance (from $24.00 to $25.50) and the maintenance of high prices for several months actually took place. Concerning the certainty of a decline, we said:

When or where the point of maximum prices will be reached, from which point there will be probably a sudden and a very great decline, is a thing no one can predict. That it will come some day is certain, and that day will be just when the statistics show that the producing capacity of the furnaces has caught up to the demand and that stocks of pig iron at the furnaces are beginning to accumulate. The demand itself may be checked by the high prices. The supply will certainly increase, not by the blowing in of old and small furnaces, but by the new and larger furnaces which are now being built.

An inspection of our diagram of prices and of stocks at the furnaces show how accurate was our prevision of the course of the market. The very moderate increase in stocks from December to April prevented any further rise of prices, and in the last month of the period led to a slight decline. The statistics for April 1, published about the middle of the month, showed both a decrease in the rate of production and an increase in stocks. Consumers suddenly refused to buy at quoted prices, and during the month of May the prices were recorded as nominal, there being no transactions. Then followed a rapid blowing out of furnaces, a still more rapid shrinkage of the demand, and a steady fall in price, as shown by the diagram.

Not only has production caught up to and surpassed the demand, but the available furnace capacity is now far beyond any possible demand for the near future. It is now nearly eight months since the furnaces gave their maximum production of 298,000 tons per week, but during all this time many large furnaces have been under construction and will be ready to blow in when the market warrants it. In our issue of Nov. 9, 1899, we published a list of 19 large furnaces then building or projected, with an aggregate capacity estimated at 2,600,000 tons per annum, or about 20% of the then annual rate of production of the country.

What of the future? Prices have now receded from the maximum of 150% above what may be called the normal price in ante-boom times, of $10 per ton, to 40% above. Will they stay where they are for awhile, or will they soon go lower? Judging from the state of the demand, and the ac-

cumulation of stocks, they should go to a much lower point than they have yet reached; but there are reasons for a contrary course. The cost of labor in all branches of the industry, and of freights by railroad and lake, is higher than it was in 1898, and this cost is not likely to be reduced at the present time, when the general business of the country is prospering. The slackened demand is not a normal demand; it is the demand of a waiting market, of customers afraid of a presidential election, and of still lower prices. When buyers make up their minds that prices have touched bottom, buying will increase rapidly, furnaces will be blown in to meet the demand, and a steady and very large business will be done at reasonably steady prices. The boom is over; the reaction is come, but it will be of short duration, and the rebound will soon carry us back to good business conditions.

It is instructive to compare the boom through which we have recently passed with the other great boom which took place twenty years before. We give the figures of pig iron prices of the two periods below, and have plotted them in the accompanying diagram. The booms were precisely alike in most of their features, with one prominent exception. The cause of each was the same, viz.; the lack of sufficient capacity for production to meet an enormous demand following, and caused by the reaction from several years of

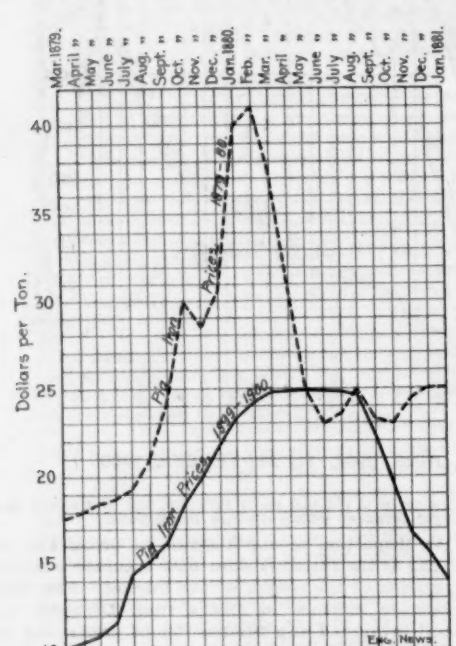


Fig. 2.—Prices of Pig Iron, 1879-80, and 1899-1900.

depression. The panic of 1873 and that of 1893 each caused a great shrinkage in the demand for iron, lasting for five years. Just as soon as the depression ended, every consumer of iron entered the market in a hurry to buy, and the abnormal demand sent prices bounding upwards. As soon as enough furnaces could be built and put in blast to meet this great demand, buyers were no longer in a hurry to buy, and prices dropped, but it may take years to bring them to their former low level. It took six years after the boom of 1879-80.

The one feature of the boom of 1879-80 which was not reproduced in the recent boom, was a craze of speculation, which sent prices from $28.50 per ton in November to $41 in February, with the consequent collapse which sent them down to $25 in May. During three or four months, "privileges," "puts and calls," etc., on pig iron were dealt in by people who knew nothing whatever about pig iron, and many fortunes were made and as many lost by this form of gambling. The result of this speculation on the trade at large was disastrous. The price of ore and of freights doubled, and that of coke went up from $1 to $5 per ton. Many producers were caught with long contracts for raw material at high prices, and failures in the trade were numerous.

The boom of 1899-1900 happily escaped this speculative feature, and the result was a steady market at maximum prices for six months, as shown by the long nearly level line at the top of the diagram, instead of a feverish market with maximum prices for only two months, as in 1880. There being less fever, the period of recovery has also been calmer. There have been no failures in the trade, and no great excitement.

The course of prices after the collapse of the boom in 1880 may be of some use in helping to prognosticate their course hereafter. The table

		Anthracite Foundry No. 1 pig at Philadelphia per gross ton.			Bessemer pig at Pittsburg.
March,	1879	$17.88	Nov.,	1898	$10.15
April	"	18.00	Dec.,	"	10.60
May,	"	18.50	Jan.,	1899	10.90
June,	"	18.75	Feb.,	"	11.60
July,	"	19.25	March,	"	14.60
August,	"	21.00	April,	"	15.00
Sept.,	"	24.25	May,	"	16.20
Oct.,	"	30.00	June,	"	18.50
Nov.,	"	28.00	July,	"	20.00
Dec.,	"	30.50	August,	"	21.70
Jan.,	1880	40.00	Sept.,	"	23.30
Feb.,	"	41.00	Oct.,	"	24.18
March,	"	37.50	Nov.,	"	24.78
April,	"	31.00	Dec.,	"	24.90
May,	"	25.00	Jan.,	1900	24.90
June,	"	23.00	Feb.,	"	24.80
July,	"	23.50	March,	"	24.90
August,	"	25.00	April,	"	24.70
Sept.,	"	23.25	May,	"	nominal
Oct.,	"	23.00	June,	"	19.75
Nov.,	"	24.50	July,	"	16.75
Dec.,	"	25.00	August,	"	15.50
Jan.	1881	25.00	Sept.,	"	14.00

and the diagram, Fig. 2, show that in June, 1880, the price touched the minimum point of $23 per ton, but it at once reacted, and during the year fluctuated between $23 and $25, closing at the latter figure. The average figure for 1881 was $25¼; for 1882, $25 3-5; for 1883, $22⅝; for 1884, $19¼; and for 1885, $18. The low figure of March, 1879, before the boom, viz., $17.88, was not again reached until May, 1885, or more than six years. If a similar course of prices is to follow the end of the boom period which has just passed, with ante-boom and post-boom figures in the same ratio, the price of Bessemer pig iron at Pittsburg will fluctuate between $13 and $14.50 for the next two years, and we will not see $10 pig iron again for six years.

LETTERS TO THE EDITOR.

Sewage Sludge Disposal at Brockton, Mass.

Sir: As noted in your abstract of the report of the City Engineer of Brockton, Mass., for 1899, in the Engineering News of March 29, 1900, all the sludge rakings removed from the sewage filter beds in 1899 were given to farmers residing in this vicinity for use as fertilizer. This course has been pursued this year, up to the present time, and those who have used the sludge have obtained such good results that several of them were simultaneously struck with the idea of securing the entire amount of sludge in the future, and made cash offers for the same. Accordingly, the sewerage commissioners have sold to the highest bidder all the rakings that will be removed for one year, beginning this fall, for $125.

Considering the difficulty experienced at other disposal plants in getting rid of their sludge deposits, the above fact is worthy of note. Bearing in mind, however, the yearly increase in the cost of caring for the sludge, and wishing to ascertain if some cheaper method cannot be followed, the commissioners have had constructed for experimental use a septic tank of about 1,100 gallons capacity. It is my intention to try using this tank both open and covered, and at various rates. Owing to the sewage flow at the beds not being continuous, a storage tank has also been provided from which a uniform flow of sludge is delivered into the septic tank by means of a movable outlet controlled by a float.

I have had the tank in operation as an open septic tank for three weeks, obtaining very good results, which, with other data to be derived, will appear in the yearly report of this department. During 1899 the sludge showed by analysis to have in parts per 100,000, albuminoid ammonia to the amount of 5 to 6 parts, and total solids 250 to 350 parts.

If the septic treatment proves to be successful it is the intention of the commissioners to construct tanks at the filter beds capable of dealing with our entire daily sludge dose of about 60,000 gallons.

No attempt will be made to treat the ordinary sewage by this method, as no deposit occurs on the beds to which sewage alone is applied.

In 1899, 1,108.4 tons of sludge rakings were re[illegible]d, and in the first six months of 1900, 677.5 tons.

Yours very truly, Geo. E. Boll[illegible]
Chemist in Charge Purification W[illegible]

Brockton, Mass., Aug. 28, 1900.

In Defence of the Dromedary.

Sir: We thank you for your appreciative notice [illegible]he Dromedary Mixer in your issue of Sept. 6, and w[illegible]ay add that the references to it in the letters we have [illegible]ce received attest the value of Engineering News as a m[illegible]m for reaching the attention of that part of the bu[illegible]ss world in which we live and move and have our being.

Our high regard for the beast whose name we have [illegible]r-rowed, in all reverence, requires, however, that we sh[illegible]ld notice one thing in your article, and should sugge[illegible] to you that there are points about his name and pe[illegible]ree which may have escaped you.

In the first place, a "dromedary," when properly v[illegible]al-ized, is a drumedary; and ours is a drum to begin with. Then there is a popular confusion about the dromed[illegible]y's humps—as to the number of the same, whether the[illegible] be one or two. This we have met by showing, what is a fact, that a dromedary may have one or two humps. Observe that we show one in Fig. 3 and two in Fig. 4 of our catalogue. This zoological fact every one of our Dromedaries consistently teaches in the regular course of business.

The remoteness of the front drivers, the aloofness, as it were, of the extremes, a thing which men learned in carts, have several times condemned at the first blush (and blushed to have condemned but a little later), is in close imitation of the lines of beauty of our Oriental namesake. The dromedary has a neat, quite, business-like, striding progress which we have always admired and at last imitated successfuly. If you will refer to the Century Dictionary you will find that the dromedary is essentially a blooded beast, a thoroughbred, related to the ordinary camel as the hunter to the hack horse. How then, let us ask, can you say: "It has been christened the 'dromedary' mixer, not, we believe, with any intention of disrespect to the beast which furnishes the motive power, but," etc.

We hope you and the dromedary may become better acquainted.

Yours truly,
Fisher & Saxton.

Washington, D. C., Sept. 13, 1900.

(What we had in mind when we penned the sentence to which our correspondent takes exception was the custom of the old-time wielder of the shovel as he threw the last scoop of dirt on the dump cart, to wake the sleeping horse with a whack and the salutation: "G'long y'ole camel." There were usually humps enough on the horse to justify the name; and while it may have been bestowed in all kindness, it was never considered exactly complimentary. This was why we explained to our readers that the new concrete mixer was named "dromedary" because of the humps on the cart, not those on its motive power.—Ed.).

Setting Slope Stakes in Cross-Sectioning Earth Work.

Sir: The letter of Mr. H. P. Gillette in your issue of Sept. 13 is but one more illustration of the adage that there is nothing new under the sun. The slope tape and special level rod which he describes have been used in the classes in surveying at the University of Michigan by Prof. J. B. Davis for the past nine years, to my personal knowledge, and how much longer I cannot state. I have used the slope tape repeatedly, and on Division No. 2 of the Copper Range R. R. (Eng. News, May 31, 1900), in 1899, I used no other method for staking out cross-sections. There is no question as to its merit, but Mr. Gillette can scarcely claim priority of discovery unless his records will show more than a decade of its use.

C. G. Wrentmore,
Structural Department, Cambria Steel Co.

Johnstown, Pa., Sept. 14, 1900.

Sir: I notice that the question of setting slope stakes is again brought to the front this week (Eng. News, Sept. 13, 1900). It seems to me that many of the ideas advanced must be somewhat amusing to the veteran resident engineer. I am aware, however, that many useless figures are sometimes made, although not as many, it seems to me, as would be made by attempting to use any "formula." For instance, I once knew an engineer of considerable experience in railway construction who invariably carried along his regular instrument height (above datum) only, and in setting stakes would always get cut (or fill) by getting elevation of ground above datum and then get the difference between that and grade in order to get cut or fill, i. e., make two sets of figures always, instead of one. If there be any way of doing this work better than using a good self-reading rod, of such design as the user prefers, with a "Ward's tape," I have never heard of it. Use instrument height in reference to grade at each cross-section, ignoring (for this purpose) datum. Then one subtraction (or addition), usually mental, gives cut or fill, and a reading on the back of the tape shows at once if

the rod is at the proper point for the stake. If not, it is a small matter to repeat the operation. I am well aware of the truth of Shunk's remark that "setting slope stakes is like following, easier done than described," and am led to write this more in the hope of saving some young man the trouble of trying to insert a lot of mathematics into the operation than from any idea, however slight, that I can give the experienced engineer any points.

Yours truly, O. H. Tripp,
Assoc. M. Am. Soc. C. E.

Rockland, Me., Sept. 14, 1900.

Railway and Engineering Work in Egypt.

Sir: The Egyptian government has just decided to increase its floating debt by £1,700,000 and to hand over this sum to the Railway Administration in order that the railway communications generally and the rolling stock may be improved. How this large sum is to be spent is not exactly known at present, but we hear that, besides doubling about 56 miles of track, they intend to make a line from Salhieh to Port Said. The object of this line is to connect that port with the interior of the Delta and to give it a share of the cotton freightage of which the Port of Alexandria has hitherto enjoyed an undisturbed monopoly. We may expect that the inland transport and sea freight of a third of the Egyptian cotton crop will thus be reduced. Whether the line takes a direct course and boldly crosses the Lake Menzaleh, a distance of 40 miles as the crow flies, or sneaks along the bank of the Suez Canal, the cost of constructing this line and providing rolling stock will be little less than £300,000.

The above extensions will necessitate the ordering of a very considerable amount of rolling stock, of which America will no doubt get her share. During the past 12 months the Railway Administration has received 400 30-ton coal cars from America, and the Baldwin works have supplied 20 72-ton engines. Lately we saw landed at Alexandria two formidable locomotives, which we were told would weigh 107 tons in running order. These engines were made by the Brooks Locomotive Works, and have duplicate wheels and axles so that they can be erected as the Atlantic or Mogul type. They are quite a new departure, as far as Egypt is concerned, for the heaviest engine now on the line does not weigh more than 72 tons.

The railway engineers are busy strengthening their track and bridges, and are sanguine in their expectation of success.

While we write we see pieces of six steam coal hoists being discharged onto the Alexandria quay, and notice that they are made by the Brown Hoisting & Conveying Machine Co., of Cleveland. These machines, called by the makers "Independent Truss Bridge Tramways," are designed to unload coal from the holds of ships lying alongside and dump it on the quay or into trucks—2,160 tons of coal in a day of 10 hours! Working their hardest, the coal men have hitherto been able to discharge only 984 tons in a long day. This is again a novelty, as far as Egypt is concerned.

About 20 years ago an engineer endeavored to introduce machinery for elevating and discharging grain; but he and the interested grain merchants had to abandon the idea in consequence of the opposition from the natives engaged in the work. We trust they have learned wisdom since then.

The high price of iron and steel has caused a general stagnation in orders for rails, bridges and roofing. We hear that the Railway Administration are about to invite tenders for 7,500 tons of Vignole rails of heavy section. If their engineers have taken to heart the good advice given them by Mr. Albert Ladd Colby in his "Review of American Standard Specifications," we may expect to hear that they will get rails at a cheaper rate than they have hitherto done, and, while English coal is maintained at its present figure, we may expect to see American locomotives steamed with American coal running on American rails.

It may interest some of your readers to learn that best kitchen coal (bad at that) is sold in Cairo at £2 12s. ($12.60) a ton, double the price it was three years ago.

A. J. C.

Alexandria, Aug. 24, 1900.

The Proposed New Method of Nominating Officers in the American Society of Civil Engineers.

Sir: The proposed amendment to the constitution of the American Society of Civil Engineers, for which ballots are to be canvassed on October 3 next, was ordered to be voted upon at the recent business meeting of the annual convention, held in London. It is probable that the effect of the amendment has not been as carefully considered as would be desirable. The proposed amendment is as follows:

Amend Article VII, as follows:

Section 2. * * * Strike out this section and substitute the following:

"2.—At the annual meeting of each year, seven corporate members, not officers of the society, one from each of the geographical districts, shall be appointed by the meeting to serve for two years; who, with the five living last past-presidents of the society, shall be a committee to nominate officers for the society.

"The board of direction may prescribe the mode of procedure for appointing this committee.

"The committee so appointed shall meet at the annual convention of the society, and nominate candidates to fill the offices, named in Article V, so as to provide, with the officers holding over, a vice-president and six directors residing in District No. 1, and twelve directors divided equally, with regard to number and residence, among the remaining districts, Nos. 2, 3, 4, 5, 6 and 7.

"A list of nominees for the offices to be filled at the next annual election shall be presented by the committee to the board of direction within ten days after the nominees have been selected."

It will be noted that the principal changes contemplated are: That the nominating committee shall be chosen at the annual meeting in January, and that the committee shall meet and nominate officers at the annual convention.

In favor of the amendment, it may be said that the appointment of the nominating committee in January allows it more time to consider and select nominees, and that it may be easier to secure a general attendance of the members of the committee at the annual convention than at any other time.

Against the amendment it may be urged:

1. The annual meeting is always held in New York, and the membership at large is not usually as fully represented at that meeting as at the annual convention. For this reason the annual convention would seem to be the best time for the selection of the nominating committee.

2. It is doubtful if the annual convention is the best time and place for the meeting of the committee to make nominations. Between the regular work of the convention and the social functions of the occasion, the time of members in attendance is usually closely occupied, and it is probable that the committee could do its work better at a time and place free from the distractions of the annual convention.

3. The committee would very properly wish to know whether the persons nominated by it would accept the positions offered, before reporting the result to the board of directors. This would probably be impossible under this amendment.

The annual convention occurs during the vacation of the society and, excepting the meeting of the board held during the convention, no other meeting occurs before the stated time in September. If "reporting to the board" means reporting to a meeting of the board, which would seem to be the correct interpretation, the committee must report its nominations to the board within one or two days after its meeting, and the acceptance of nominees could hardly ever be obtained within that short time.

4. One of the features of the present plan of nominating officers that has been thought very unsatisfactory by many is the method of appointing the nominating committee. The proposed amendment does not attempt to deal with this feature, but leaves it, as does the present constitution, to be formulated by the board of directors.

It is evident that there is much dissatisfaction among the membership with the present method of nominating officers, but the proposed amendment does not seem to offer a satisfactory substitute. Would it not, therefore, be advisable to defeat its adoption, and to refer the whole matter of nomination of officers to a committee of members, who would give the subject careful consideration and, if possible, report a scheme that will obviate the objections to the present method?

While the time is short, it is not yet too late for those members who have already voted in the affirmative to recall and change their ballots. Very truly yours,

M. Am. Soc. C. E.

New York, Sept. 18, 1900.

Stray Notes of Municipal Work.

(Editorial Correspondence.)

Sir: The public works of Milwaukee give evidence of having been developed by a master mind, not hampered at every turn by incompetent associates in the city governments. In these respects there is a striking contrast between Milwaukee and Columbus, O. In the latter city many men of many minds seem to have held in check urgent municipal improvements for a number of years past, largely through unwillingness to be guided by their engineering advisors. The general impressions of public works in Milwaukee, as viewed during a busy convention week, are favorable. More river flushing is necessary to make the city thoroughly presentable, and in the matter of garbage disposal Milwaukee is in the same plight that Columbus is in with regard to water supply and sewage purification. This is hardly strange; for thus far Milwaukee has scarcely looked upon garbage disposal as an engineering problem and consequently it has floundered about in its own dirt for years past. It is true that legal difficulties have caused several delays at Milwaukee, but if the best legal and engineering talent had been brought to bear upon the problem five years ago, it is probable that the city might have had model garbage disposal works before this. Instead it has turned back from the reduction works, described in Engineering News a few years ago, to the most primitive means of ridding itself of its wastes.

It sems strange that the swing drawbridges of Milwaukee, in the most crowded sections of the city, should be wholly unprotected by gates. After the bridges begin to turn, people continue to go on them so long as they can step or jump on and there is nothing to prevent a person from walking off the abutments.

Columbus now has what seems to be a very good system of garbage collection and disposal, as described in our issue of July 19, 1900. The city engineer, Mr. Julian Griggs, M. Am. Soc. C. E., has made innumerable plans for sewage treatment and an elaborate report on that subject was submitted about a year ago by Alvord & Shields, of Chicago. The matter now rests with a local commission. A number of reports on a new water supply have been secured from outside engineers during the past few years and steps were taken a while ago to let a contract for a dam, but legal and other complications have prevented the starting of work. Mr. Samuel M. Gray, M. Am. Soc. C. E., of Providence, R. I., is to report on the water supply question soon.

The abominable condition of some of the asphalt paved and other streets of Columbus fully justifies Mr. Kemmler's assertion, on which we commented in our issue of Sept. 6, that Columbus knows nothing about street maintenance.

In striking contrast with Columbus were some miles of asphalt and brick pavements seen in Detroit. The city pays $35,000 a year for repairs of its asphalt streets alone, under a contract with the Barber Asphalt Co. Bids have been received for a municipal asphalt plant at Detroit, designed chiefly for repair work. Hetherington & Berner, of Indianapolis, offered to put up a plant for about $10,000, which it is thought would be sufficient for the purpose named.

The elimination of grade crossings in Detroit has been begun at Woodward Ave., where the Michigan Central, Lake Shore and Grand Trunk railways cross the street side by side. In all, there are about 150 crossings to be removed.

For the convenience of contractors, and to save time and expense, drawings of new lateral sewers, with all facts necessary for bidders, are pinned on the wall in the city engineer's office. The drawings are on Whatman paper, 15 × 18 ins. in size, and are eventually bound up and filed away. Mr. Robert H. McCormick, M. Am. Soc. C. E., is city engineer of Detroit.

The spacious area about the city hall at Detroit is a pleasure to behold with its broad, smooth asphalt paving and the lawn and foliage plants close by the building.

Detroit is to have two new 24,000,000-gallon pumps and a division of its distribution system into high and low service, using the old pumps for the latter. The dividing line will be 50 ft. above the river, but the maximum high service level is only 70 ft. above the river. The whole city is supplied by direct pumping, the standpipe not being used. Hourly, as well as daily, pumping records are kept.

Preliminary studies for filtration have been in progress for some years. The water carries an objectionable amount of suspended matter at times. Mr. C. W. Hubbell, Jun. Am. Soc. C. E., the civil engineer of the waterworks, believes the cost of reducing water waste at Detroit has been more than the gain, owing to the low cost of water in Detroit. As a matter of equity he believes in meters and thinks they will be required in Detroit when the water is filtered.

A few years ago, one of the principal streets of Detroit was cleaned by flushing with hose. Mr. Hubbell says the work was well done by flushing twice a week and using water equal in amount to a depth of 0.2 ft. over the whole area for each flushing, but the plan did not give satisfaction. It was expensive, even with the cheap water at Detroit. People did not like to have the streets so wet and it was feared that the asphalt would be injured if the practice was continued.

The park around the water-works station at Detroit is a very pleasing feature, which might well serve as a hint to other cities.

The way in which asphalt will deteriorate when not subjected to the compressive action of traffic seems to be well shown at Indianapolis, on streets having a central line of trolley poles. The asphalt in the space between the two tracks, in the center of which are the poles, is badly cracked, and the asphalt between the rails of each track is in a much worse condition than that outside the tracks. Some handsome wooden pavements, down about a year, were noted, but some down about three years were quite uneven, said to be due to improper foundations.

Mr. B. J. T. Jeup, the city engineer, said the recent ruling by the state supreme court, declaring the Barrett assessment law constitutional, would permit a resumption of street and sewer work in Indianapolis and throughout the state. Some large Melan arch bridges are now being built by Mr. Jeup.

The soldiers' monument in Indianapolis is a commanding central feature. There are two immense cascades in connection with it, which the state maintains by repumping the water.

The Indianapolis Water Co. is building a large new pumping station, and has plans for filtration under consideration. There is quite a bit of iron precipitated from the well water delivered by the air-lift pumps, but this settles in the old filter gallery, which was covered with a light, flat board roof a year or two ago. The company has a greenhouse near its pumping station, and is building a 40 × 40 ft. palm house. It is developing a fine park, all of which is not only highly commendable as public spirited action, but will undoubtedly pay. Mr. F. A. W. Davis is vice-president and manager of the company.

A limited opportunity for observations in Chicago was sufficient to impress one with the dirtiness of its streets

and the great improvement in the appearance of the Chicago River since the drainage canal was put in operation. The North Branch of the river is a reminder of the foul condition of the main stream in former days.

Wheaton, a small suburb of Chicago, about 25 miles west on the Northwestern Ry., has much to learn about street construction. Gravel is used to improve some of the streets, but it is applied in a primitive way, apparently without any rolling. One stretch of new gravel was observed, some 8 to 10 ft. wide and 18 to 24 ins. high in the center, which had been awaiting traffic for compressing it for some weeks or months, but had been shunned by horse and man.

Notes and Queries.

A correspondent requests a solution of the following problem: A girder bent in the form of a true circle rests on four points of support spaced equidistant in the same horizontal plane. This girder is uniformly loaded. Wanted, a derivation of the bending moments at the points of support, and also at the center of the span, or for any other point.

Mr. F. Stuart Williamson, M. Am. Soc. C. E., Inspector Cape Government Railways, referring to the statement in Engineering News of Aug. 30, 1900, that an order for 4,000 tons of rails for these railways has been placed with the Carnegie Steel Co., writes:

This is correct as far as it goes, but as far back as January an order for 3,000 tons was placed, and in June a further order for 4,000 tons. Since then an order for frogs, switches and other railway material has been given to the Union Switch & Signal Co. Other orders are to follow.

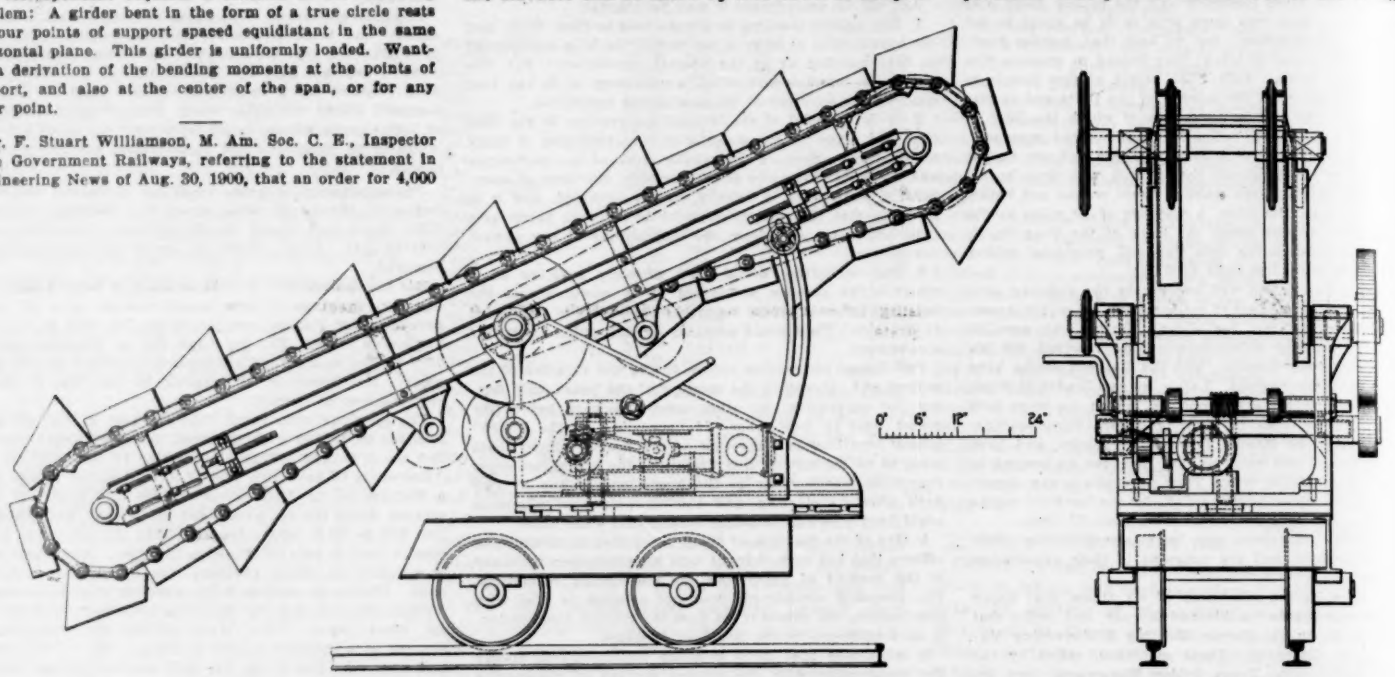
"Canadian Reader" writes: "In your editorial of Sept. 13 you compare Canada to 'America, England and Germany.' Does it not seem about time that the absurdity of citizens of the United States laying claim to being the only people entitled to be called Americans should be dropped?"

We admit the slip in speaking of the United States as "America;" yet in popular usage on the other side of the ocean the expression is not uncommon. The designation of residents of the United States as "Americans" especially is too firmly fixed to be altered. Curiously enough, on the recent visit of the American Institute of Mining Engineers to Nova Scotia, the resident engineers who welcomed the visitors made evident their preference for the term "Canadian" as applied to themselves; and in reply to Secretary Raymond's suggestion that the American Institute of Mining Engineers was continental in its scope, called attention to the prosperous Canadian engineering societies.

AN EXCAVATING AND LOADING MACHINE FOR TRANSFERRING ORE TO RAILWAY CARS.

We illustrate in the accompanying cut the general details of an excavating and loading machine, built by the Jeffery Manufacturing Co. of Columbus, O., for the Fayal Iron Co., of Fayal, Minn., and employed by that company for loading ore from their mines into cars. The machine illustrated is the first one built, and while it has worked well as far as the principle of construction and operation is concerned, some of the parts have proved unable to withstand the great strains and will have to be strengthened to make it a permanent success. It is the intention of the builders to remodel the design and strengthen the weak parts by heavier construction and to offer the machine for sale for all kinds of excavating and loading work for which its character is suitable.

The accompanying drawings show the general construction of the machine so fully that very little description is necessary. It will be noticed that the principal part is the elevator, which consists of two strands of roller chain covered alternately with pans and buckets. The buckets are intended to pick up or excavate the load while the pans assist in carrying and delivering it to the cars. The elevator is mounted on a platform pivoted to a small car, so that it can be moved from place to place. By means of the pivot connection the elevator can be tilted up and down to adopt it to various depths of excavation and heights of elevation. The power to operate the elevator is supplied by a small horizontal engine mounted on the car body and operated by compressed air. The manufacturers also suggest the use of electrical power for operating the mechanism. We are indebted to the Jeffery Mfg. Co. for the information from which this brief description has been prepared.



Side Elevation. End Elevation.

EXCAVATING AND ELEVATING MACHINE FOR LOADING IRON ORE INTO CARS; FAYAL IRON CO., FAYAL, MINN.
Jeffrey Mfg. Co., Columbus, O., Builders.

RAILWAY TRANSITION CURVES.

By F. K. Vial.*

The benefits arising from the introduction of transition curves to railway alinement are now so universally recognized that it is important that instrument men should be familiar with spirals and ready methods of adapting them to any case that may arise. The number of articles that have recently appeared in the engineering journals relating to spirals, indicate a demand for simple methods for field use. The writers on transition curves, who have developed special tables for field practice, are numerous, and among them may be mentioned the following: Elliot Holbrook, who described the curve in 1880; Wm. H. Searles, in 1882; C. D. Jameson, in 1890; A. N. Talbot, in 1891; O. L. Crandall, in 1893; W. G. Fox, in 1893; A. Torrey, in 1893, and C. R. Howard, in 1894. Treatments of spirals are also found in the field books of Henck, Nagle, Godwin, Frost, Allen and others, all of which are more or less valuable. It may seem presumptuous to attempt to add anything to what the above writers have brought out, but while there is nothing more to be desired in the way of theory, there is an opportunity to simplify the method of treatment, and to tabulate results that are of a general nature instead of following the custom of making tables for [illegible] or less numerous special cases.

In one method of treatment of spirals [illegible] deflection angles is calculated, which [illegible] constant for every rate of transition, the [illegible] rate of change being obtained by vary[illegible] the chord length. This method is used by [illegible] and Howard. In the other method, which [illegible] followed by most of the other writers, the d[illegible] angles change with the rate of transitio[illegible] The alinement of track by either method gives [illegible] good results. The form of spiral to be [illegible] will depend on its ease of application and [illegible] cility with which it may be adapted to the [illegible] problems that present themselves to the e[illegible]

*Assistant Engineer; Chicago & Western Indiana R. R.

in charge of alinement. That method which depends wholly on offsets from the tangent or circular curve will not be considered in this discussion, for while it may have its place in location work, there is nothing to be gained by its use in setting track centers, as it requires more labor and is less reliable than either of the methods of deflections.

Any one who has had extended experience in laying out spirals frequently uses a spiral not found in the tables he may have at hand. This requires interpolation or considerable figuring, and shows the limitations of existing tables. In order to allow perfect freedom in the choice of a spiral, either in regard to the chord length or rate of transition, the tables must be constructed on a basis different from any that has come to the notice of the writer. The objects of this article are to analyze the fundamental principles which underlie the subject, and also to show how the simplest of methods can be used to demonstrate the theory, and to construct a deflection table mentally, and a general table of co-ordinates by the use of the sine and cosine.

While fully appreciating the method of demonstration involving transcendental functions, and admitting that this method is the best for those who are familiar with the differentiation and integration of infinite series of the sine, cosine, and tangent, yet it is a fact that many field engineers do not follow through such demonstrations as developed by Holbrook, Talbot, Crandall, Jameson, and others, far enough to familiarize themselves with the working formulae or to intelligently apply the tables in field practice. In fact some of the writers discourage the instrument man in attempting to understand the demonstration of "Formulae too complicated for convenient use" by stating that "A knowledge of the demonstration is not essential to the application of these formulae to field work." The demonstration herein given, which is original with the writer, can read-

lly be followed by "Engineers not mathematically inclined," and it is believed that a thorough understanding of this simple demonstration cannot fail to enable the assistant to perform his field work more intelligently than by following tables the derivation of which he does not understand.

The Railway Transition Spiral.

The transition curve best adapted to railway alignment is the railway transition spiral first described by Holbrook as one in which the degree of curvature increases directly as the distance from the point of spiral. It is with this form of spiral that this article is chiefly concerned. In Fig. 1, consider the chords of equal length, and

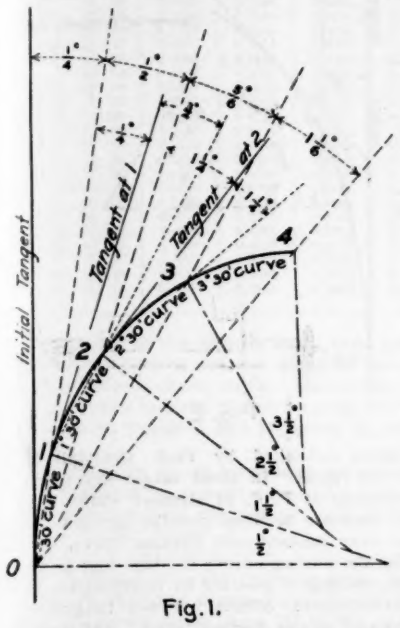


Fig. 1.

each subtending a circular arc, the central angle of each arc being greater than the last preceding by a constant angle. This common difference is called the rate of transition. For convenience in demonstration, consider each chord a station of 100 ft., and the central angle of the first chord ½°, and let the rate of transition equal 1°, then the successive angles at the center become ½°, 1½°, 2½°, 3½°, (n — ½°), in which n equals the number of chords, or the chord point at the further end of any chord. The degree of curve in each arc in this case is the same as its central angle.

Let △ = the total central angle, then by arithmetical progression $\triangle = \frac{½° + (n - ½)°}{2} n = \left(\frac{n^2}{2}\right)°$

or to make the expression general for any chord length we may use r (rate of transition per chord) instead of the sign of degrees thus:

$$\triangle = \frac{n^2}{2} r. \qquad (1)$$

The degree of curvature for any arc equals $\frac{\text{angle subtended by arc}}{C}$, in which C equals the length of the chord in feet divided by 100.

The central angle for any length of arc is the sum of the deflection from the point of spiral to the end of arc and the back deflection from the end of arc to the point of spiral.

To Show That The Deflection Angle From the Point of Spiral to Any Point is ⅓ the Total Central Angle to that Point.—To make the demonstration conform as nearly as possible to the method used in circular curves, assume an instrument man in the field without tables or a knowledge of spirals other than that given above, how would he proceed? With the instrument at the point of spiral the deflection to first chord point is ¼° (considering now that each chord subtends a circular arc). He would then move the instrument to Sta. 1, back sight on Sta. 0, and turn ¼° to get on the auxiliary tangent through Sta. 1. The deflection from this tangent to Sta. 2 is ¾°, or the angle between the first and second chord is 1°. Then the angle between the first chord and the long chord from Sta. 0 to Sta. 2 is ½°, since Sta. 1 lies half way between Sta. 2 and Sta. 0 (consider the sines to vary directly as the angle). Notice that this increment ½° is ⅓ of the angle at the center for the second chord. By continuing this method it will be found that this ratio of the deflection increment to the corresponding central angle increment is constant. The sum of the deflection increments then becomes ⅓ △ + 1-12°, since all the increments to the deflection angle, are ⅓ the corresponding central increment, except the first which is 1-12° greater. To make the expression general, use r, instead of (°), when the deflection to any chord point becomes ⅓ △ + 1-12 r.

To express the above deflection increment algebraically: note that the increase in the deflection from any chord point n, to the next point (n + 1) is made up of the sum of the back deflection, from the point n, and ½ the central angle of the n + 1 chord, divided by n + 1. We have found that the deflection from the point of spiral, to the point 1, 2, 3, etc., is ⅓ △ + 1-12r. The back deflection then is

$$\triangle - (⅓ \triangle + 1\text{-}12\ r) = ⅔ \triangle - 1\text{-}12\ r$$
$$= ⅔ \frac{n^2}{2} r - 1\text{-}12\ r.$$

Using these values we have deflection increment equals

$$\frac{⅔ \frac{n^2}{2} r - 1\text{-}12\ r + ½\ (n + ½)\ r}{n + 1} = ⅓\ (n + ½)\ r. \qquad (2)$$

But the quantity (n + ½) r is the central angle of the n + 1 chord, therefore the successive increments to the deflection angle will be ⅓ the corresponding increment to the central angle, except for the first chord, since we have considered this chord to subtend a circular are, which is 1-12 r more than ⅓ △.

This difference is insignificant when the chords are short, and becomes zero when the chords are considered as infinitesimals, and the deflection from the point of spiral to any point becomes ⅓ △. The points of compound curve are then consecutive and the degree of curve increases directly as the distance from the point of spiral which is the definition of the spiral we are describing, and is the same curve that is developed by Jameson, Talbot, Crandall, Howard and others.

The Deflection Table.

The deflection table for this form of spiral is shown in Table No. 1. The sign of degrees is omitted, making the table general so that any chord length or any rate of transition may be used at pleasure. The quantities in the table become coefficients of the rate of transition. The column headed "chord angle" is filled in directly from the figure, and the column headed "Total central angle" is filled in by adding the successive chord angles, or by using the formula $\triangle = \frac{n^2}{2} - r.$

The deflection angle for Inst. at Sta. 0 or point of spiral is ⅓ the total central angle, so the column headed Inst. at 0 can be filled in by taking ⅓ the previous column.

The deflection from any point to any other point is equal to the deflection for a circular curve of the degree of curve at the point from which the deflection is taken, to the second point, plus or minus the deflection from Sta. 0 for an equal distance. This follows from the fact that this spiral deflects from a circular curve of the same radius at the same rate it does from the initial tangent, thus the complete table is written up for the deflections from each Sta. and is checked by differences. We notice the difference between successive deflections increases by ⅓, and the differences in the successive difference columns increase by 1-6 in a horizontal direction, and ½ in a diagonal direction, also, the quantities in the deflection columns increase in a diagonal direction by ½, 1, 1½, 2, 2½, etc., depending on the distance from the diagonal line of zero deflection through the center of the table. This line gives a starting point in summing the differences. It is thus a very easy matter to check the table.

The use of Table I. can best be shown by stating an example: What are the deflections for 25 ft. intervals, in a spiral 225 ft. long, joining a 6° 10′ curve?

The rate of transition for 100 ft., is $\frac{6° 10'}{2.25} = 2°$ 44′; the rate (r) for 25 ft. is 0.25² × 2° 44′ = 10¼ min. = 615 sec.; the number of chords (n) = 9.

From Table I., opposite point 9, the coefficient for total central angle is 40½, which, multiplied by 10¼ (= r) = 6° 55′ 7.5″.

The deflections for Inst. at point and at end of spiral are shown below:

Point.	Station.	Coefficient.	Instrument at P. S. 0. Deflection.	Instrument at P. S. 0. Difference.	Instrument at 9 Deflection.	Instrument at 9 Difference.
0.	00	0	0′ 00″	0′ 00″	4° 36′ 45″	17′ 05″
1.	+25	0⅛	1′ 42.5″	1′ 42.5″	4° 19′ 40″	20′ 30″
2.	+50	..	6′ 50″	5′ 07.5″	3° 59′ 10″	23′ 55″
3.	+75	..	15′ 22.5″	8′ 32.5″	3° 35′ 15″	27′ 20″
4.	1+00	..	27′ 20″	11′ 57.5″	3° 07′ 55″	30′ 45″
5.	1+25	..	42′ 42.5″	15′ 22.5″	2° 37′ 10″	34′ 10″
6.	1+50	..	1° 01′ 30″	18′ 47.5″	2° 03′ 00″	37′ 35″
7.	1+75	..	1° 23′ 42.5″	22′ 12.5″	1° 25′ 25″	41′ 00″
8.	2+00	..	1° 49′ 20″	25′ 37.5″	44′ 25″	44′ 25″
9.	2+25	13½	2° 18′ 22.5″	29′ 02.5″	00′ 00″	00′ 00″

This example is chosen to show that even with a fractional (r) all calculations are performed mentally, thus: The first difference in Table I., with instrument at 0 is 1-6, which, multiplied by the rate 615″ = 1′ 42.5″ as the first difference. It was shown in making the table that the differences increase by ⅓ r = 3′ 25″, therefore simply add

TABLE I.—GIVING COEFFICIENTS FOR TRANSITION SPIRALS.

No. of Point. n.	Degree of Curve.	Chord Angle.	Total Central Angle.	Instrument at 0	1	2	3	4	5	6	7	8	9	10
				Def. Diff.	Def. Diff.	Def. Diff.	Def. Diff.	Def. Diff.	Def. Diff.	Def. Diff.	Def. Diff.	Def. Diff.	Def. Diff.	Def. Diff.
0	0			0	¼	1½	3	5½	8½	12	16½	21½	27	33½
					¾	¾	¾	¾	1	1½	1½	1½	1½	1½
1	1 c	¼	¼	¼	0	¾	2¼	4¼	7½	10½	15	19½	25½	31½
				¼	¾	¾	¾	¾	1	1½	1½	1½	2	2½
2	2 c	1½	2	¼	¾	0	1½	3½	6	9½	13½	18	23½	29½
				¼	1	1½	1½	1½	1½	1½	2	2½	2½	2½
3	3 c	2½	4½	1½	1½	1½	0	1½	4½	7½	11½	15½	21	26½
				1½	1½	1½	1½	1½	2	2½	2½	2½	2½	2½
4	4 c	3½	8	2½	3	2½	1½	0	2½	5½	9	13½	18½	24
				1½	1½	1½	2	2½	2½	2½	2½	2½	3	3½
5	5 c	4½	12½	4½	4½	4½	3½	2½	0	2½	6½	10½	15½	20½
				1½	2	2½	2½	2½	2½	2½	3	3½	3½	3½
6	6 c	5½	18	6	6½	6½	6	4½	2½	0	3½	7½	12	17½
				2½	2½	2½	2½	2½	3	3½	3½	3½	3½	3½
7	7 c	6½	24½	8½	9	9½	8½	7½	5½	3½	0	3½	8½	13½
				2½	2½	2½	3	3½	3½	3½	3½	3½	4	4½
8	8 c	7½	32	10½	11½	12	11½	10½	9	6½	3½	0	4½	9½
				2½	3	3½	3½	3½	3½	3½	4	4½	4½	4½
9	9 c	8½	40½	13½	14½	15½	15	14½	12½	10½	7½	4½	0	4½
				3½	3½	3½	3½	3½	4	4½	4½	4½	4½	4½
10	10 c	9½	50	16½	18	18½	18½	18	16½	14½	12	8½	4½	0

this amount to each difference to obtain the next difference, and then add these differences to obtain the deflections. The deflections for instrument at 9 are found by the same method; the first difference coefficient in Table I., with instrument at 9, is 1⅔, which, multiplied by (r) 615" = 17' 05" and the common difference 3' 25" is added successively to obtain the results given above. The deflections are obtained by starting at the bottom and adding upwards. The deflections for instrument at any other point can be found by pursuing the same method.

A valuable feature of this table is the numerous checks that are afforded, thus: Deflection 0 to 9

$$= \tfrac{1}{3}\,\triangle = \frac{6^\circ\ 55'\ 07.5''}{3} = 2^\circ\ 18'\ 22.5''$$ as above.

The deflection from 9 to 0 is $\frac{2}{3}\,\triangle = \frac{2}{3}$. 6° 55' 07.5" = 4° 36' 45" as above, or the coefficient for any point in the deflection column multiplied by 10¼ min. gives the deflection for that point.

To show that the deflection to any point is the same regardless of the number of chords chosen, the deflection from 0 to 1+00 may be found as follows:

n.	Length.	r.	Coefficient.		Deflection.
1 chord.	100 ft.	164'	0⅙	=	27' 20"
2 chords.	50 "	41'	2⅔	=	27' 20"
4 "	25 "	10¼'	2⅔	=	27' 20"
5 "	20 "	6.56'	4⅓	=	27' 20"
10 "	10 "	1.64'	16⅔	=	27' 20"

This shows the general nature of the table and the numerous opportunities for checking.

The Table of Co-ordinates.

A table of the form shown in Table II. can easily be carried out to any desired extent. The angle of each chord with the initial tangent is shown in column headed "Angle of intersection," then X is the sum of the departures of the chords to the point in question, and Y equals the sum of the latitudes. In the table, the latitude corrections are given or the sum to be subtracted from the length of spiral to give the total latitude Y. The quantities in the table are figured for a rate of transition of 1 minute per chord length of 1 ft. To find X in any case, multiply the quantity in the table by the product of the given chord length into its rate of transition. Y varies as the square of the rate of transition.

Example: What are co-ordinates X and Y to point 300 ft. from the point of spiral, the degree of curve at 100 ft. being 2°.

Use 30 chords 10 ft. long, then r for 10 ft. is $.1^3 \times 2^2 = 1.2$ min., and $X = 1.2 \times 10 \times 1.3074 = 15.69$. $L - Y = 1.2^3 \times 10 \times .0513 = .73$ or $Y = 299.27$ ft.

The quantities 1.3074 and .0513 are taken from Table II. opposite point 30.

To show how general formulae may be obtained by simple methods use the following notation, which is similar to that of Prof. Talbot. This refers to Fig. 2:

- L = length in 100' stations.
- C = length of equal chords in hundreds of feet.
- N = number of chords.
- a = rate of transition for 100-foot chords.
- r = rate of transition for any chord = difference in angle subtended by consecutive chords.
- D = degree of curve at any point.
- I = total intersection angle.
- △ = total central angle of spiral.
- θ = deflection from point of spiral.
- o = distance between parallel tangents.
- X and Y = co-ordinates to any point.
- L = C N.

Now by definition:

$D = a\,L = \frac{r\,N}{C}$, and since the rate of transition varies as the square of the chord length.

$$r = C^2\,a \text{ or } a = \frac{r}{C^2}. \qquad (3)$$

$$\triangle = \tfrac{1}{2}\,D\,L = \tfrac{1}{2}\,a\,L^2 = \tfrac{1}{2}\,r\,N^2. \qquad (4)$$

$\theta = \frac{1}{8}\,\triangle$ (previously proven) $= 1\text{-}6\,a\,L^2 = 1\text{-}6\,r\,N^2$. (5)

$X = L \sin \frac{1}{8}\,\triangle = L \sin 1\text{-}6\,a\,L^2$. Now when (a) equals 1 degree sin 1-6 a = .00291. Considering the sine to vary directly as the angle, $X = .291\,a\,L^2$. (6)

$o = X\,R\ \text{vers}\ \triangle$. But $X = L \sin \frac{1}{2}\triangle$. And $R\ \text{vers}\ \triangle = \frac{1}{2}\,L \sin \frac{1}{2}\triangle$, therefore $o = \frac{1}{4}$

$$X = .0727\,a\,L^2. \qquad (7)$$

The Proper Length of Spiral.

The rules to determine the length of spiral are often very crude. A recent editorial in the "Railroad Gazette" suggested a change in superelevation of the outer rail at the rate of 1 ft. in 600 ft. Mr. Sadler, in Engineering News of April 12, 1900, says the length of spiral should be 50 ft. per degree of curve, which is also the method used by Prof. Crandall. These rules can only apply to one velocity, therefore they are not consistent, except between very narrow limits. Prof. Talbot's suggestion that the rate of transition probably should vary inversely as the cube of the velocity, works very well in practice. The assumptions are that there should be a constant rate of change in superelevation per unit of time, and that the superelevation increases uniformly, from zero at the point of spiral to the full elevation at the P. C. C.

To Show that the Rate of Transition Should Vary Inversely as the Cube of the Velocity.

Let T = time required to pass over one station.
V = velocity in stations per second.
a = rate of transition per station, = degree of curve at end of first station.
E = superelevation per station.
e = desirable change in superelevation per second.

From mechanics:

$E = KV^2$, in which K is a constant.

$E = eT$.

$T = \frac{1}{V}$.

Substituting and reducing,

$$a = \frac{e}{KV^3}.$$

In practice it is found that half a degree per station is about the proper rate of transition for the highest velocities, say 75 or 80 miles per hour, and is thus limited to 2° curves or less.

The corresponding rates for various velocities are as follows:

80	miles per hour	use	a =	½°	for	2°	curves or	less.
60	"	"	a =	1°	"	3°	"	"
40	"	"	a =	2°	"	6°	"	"
30	"	"	a =	3°	"	10°	"	"
25	"	"	a =	5°	"	12°	"	"
20	"	"	a =	8°	"	16°	"	"

By this rule a small degree of curvature may require a longer spiral than one of greater degree, thus a 2° curve may require a spiral 400 ft. long, a 6° curve 300 ft., and a 12° curve 250 ft. By using a rate of transition twice as great as the above fairly good results may be obtained, but this would make the spiral too short when there is nothing to limit the length.

To Locate the Point of Spiral.

In short spirals it is sufficiently accurate to consider the point of spiral and end of spiral as equidistant from where the P. C. would fall if no spiral were used. (See Fig. 2.)

The exact methods laid down by the various authors cannot be improved. Thus the distance from the point of intersection to the point of spiral is $(R + O)\ \text{tang}\ \frac{1}{2}\,I + (Y - R \sin \triangle)$. Having Y given in the table it is very easy to construct a table giving sin △ multiplied into the radius of a 1° curve, so that the field calculations can be reduced to a minimum. The different ways of introducing spirals to existing curves is so well developed in the various field books that it is unnecessary to consider that part of the subject here.

To show the relation between Tables I. and II., and the tables that have been published in field-book form, a short description of a few of the best will be given.

The Howard Transition Curve.—The fundamental idea in the method used by C. R. Howard is the development of a general table by using a constant angular rate of transition of 12 minutes per chord, making the first deflection 2 minutes. The chord length is varied to obtain the desired rapidity of increase in the degree of curvature. By applying 12 minutes to the coefficients in Table I. the deflection angles in the Howard table are obtained, all other quantities in the table are obtained from Table II., and supplemental general tables for long chords, etc. The disadvantage in the use of this table is that but one chord length can be used for a given rate of transition. This the table lacks flexibility.

The Crandall Transition Curve.—The basis of

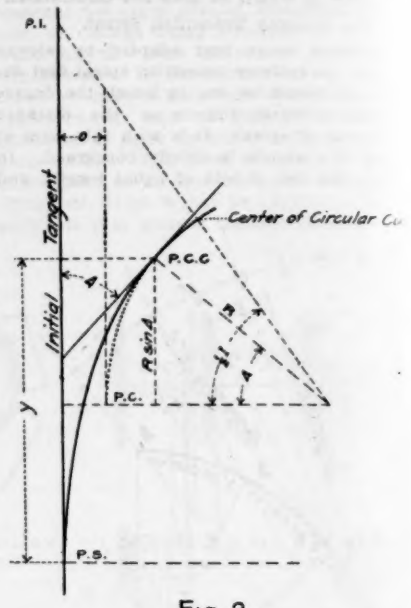


Fig. 2

the tables published by Prof. Crandall is the length of spiral. In these tables are found the co-ordinates of P. C. of circular curve, end of spiral, distance between parallel tangents, excess of arc over tangent and circular curve, for over 800 spirals, joining curves of even degrees of curvature, making it possible by interpolation to find the co-ordinates, offsets between tangents, etc., for the end of any desired spiral. The quantities in the table for deflection angles are coefficients of ⅛ the central angle for chords 1-20, 1-10, 1-5, or ¼ the total length of spiral, giving an opportunity to move the instrument to the quarter points or center of spiral. These tables are convenient in many ways, the principal objections are the necessity of interpolation and the restriction in the number of chords and instrument points; also the tables refer to the end of spiral only, no intermediate points are calculated. All the quantities for co-ordinates, and distance between parallel tangents can be taken from Table II. of this article, which is not limited to particular points.

The Jameson Method.—The method which Prof. Jameson used in preparing tables for field practice consists in assuming a certain number of offsets between tangents and tabulating spirals for these gaps for curves of even degrees of curvature, thus giving a choice of a number of spirals for certain circular curves. The same objections will apply to this method as to Crandall's, and in addition it lacks the necessary flexibility for use in the field. Tables I. and II. give all the information for these spirals and an infinite number beside.

The Talbot Transition Spiral.—The most general treatment of spirals yet published is that by Prof. Talbot in his "Railway Transition Spiral." The tables are based on a choice of eight rates of transition, and others can be obtained by multiplication. The deflections, central angles, co-ordinates, etc., are calculated at 10 ft. intervals. All deflections are from the point of spiral, and there is thus no aid in the table for the instrument man when it becomes necessary to move the instrument to intermediate points in the spiral, neither can the spiral be run in the reverse direction. These difficulties are partially overcome by the relationship developed between the degree of curve, rate of transition, length of spiral, central angle, tangent offset, etc, whereby any necessary quantity is expressed in a formula in terms of the above-mentioned elements, making it possible to calculate the deflections, etc., from any one point to any other point. These are undoubtedly the most general relations yet developed. They involve the square, cube, or fifth power of the

TABLE II.—GIVING COEFFICIENTS FOR COORDINATES OF TRANSITION SPIRALS.

No. of Chord.	Angle of Intersection.	Chord Departure.	Total Departure.	Chord Latitude Correction.	Total Latitude Correction.
	0° 0′ 10″	0.0000	0.0000	0.0000	0.0000
	01 10	0.0003	0.0004	0.0000	0.0000
	03 10	0.0009	0.0013	0.0000	0.0000
	06 10	0.0018	0.0031	0.0000	0.0000
	10 10	0.0030	0.0061	0.0000	0.0000
	15 10	0.0044	0.0105	0.0000	0.0000
	21 10	0.0062	0.0166	0.0000	0.0000
	28 10	0.0082	0.0248	0.0000	0.0001
	36 10	0.0105	0.0353	0.0001	0.0001
	45 10	0.0131	0.0486	0.0001	0.0002
	55 10	0.0160	0.0645	0.0001	0.0003
1	06 10	0.0192	0.0838	0.0002	0.0005
1	18 10	0.0227	0.1065	0.0003	0.0008
1	31 10	0.0265	0.1330	0.0004	0.0011
1	45 10	0.0306	0.1636	0.0005	0.0016
2	00 10	0.0349	0.1986	0.0006	0.0022
2	16 10	0.0395	0.2382	0.0008	0.0030
2	33 10	0.0445	0.2827	0.0010	0.0040
2	51 10	0.0498	0.3325	0.0012	0.0052
3	10 10	0.0553	0.3878	0.0015	0.0068
3	30 10	0.0611	0.4489	0.0019	0.0086
3	51 10	0.0672	0.5160	0.0023	0.0109
4	13 10	0.0736	0.5896	0.0027	0.0136
4	36 10	0.0802	0.6699	0.0032	0.0168
5	00 10	0.0872	0.7571	0.0038	0.0206
5	25 10	0.0944	0.8515	0.0045	0.0251
5	51 10	0.1020	0.9535	0.0052	0.0303
6	18 10	0.1098	0.0633	0.0060	0.0364
6	46 10	0.1179	0.1812	0.0070	0.0433
7	15 10	0.1262	0.3074	0.0080	0.0513

length of spiral to the desired point, thus making some of the solutions tedious while in the field, while they give no check on the calculations. Any of the quantities in Prof. Talbot's tables are readily taken from Tables I. and II., given in this article.

Thus, while the above-mentioned authors have developed tables for special cases, the tables developed in this article are general, and, therefore, cover all special cases.

To show the application of the various methods to field problems take the example given by Mr. Sadler in Engineering News, April 12, 1900:

Given the intersection angle (I) = 80° between two tangents to put in a 6° curve with a spiral on each end 300 ft. long.

The rate of transition per station is 2 degrees.

The rate of transition per 50-ft. chord is 30 minutes.

The rate of transition per 10-ft. chord is 1.2 minutes.

The central angle of spiral from Table I. is 9°, which is found by taking any of the co-efficients in the column headed total central angle and multiplying by the proper rate of transition, thus $18 \times 30'' = 9°$ or $4\frac{1}{2} \times 2° = 9°$ or $\frac{1}{2} \times 18° = 9°$.

From Table II., opposite No. 30, X coefficient = 1.307.

$o = 1.307 \times 10 \times 1,2 \times \frac{1}{4} = 3.92$ ft. (since $0 - \frac{1}{4}$ X) (see general formulae). Tang. dist. = Tang. 40° (955.37 + 3.92) + Y — (sin 9° × 955.37) = 954.8 ft. P. I. = Sta. 19 + 50.9, P. S. = 9 + 96.1, P. C. C. = 12 + 96.1, E. C. C. = 23 + 29.1, P. T. = 26. + 29.1. Notice that the second part of the above equation is .1 ft. less than ½ the length of spiral, which accounts for the difference in Tang. dist. in the two articles. Mr. Sadler's (original) formula (6) (which is simply a part of equation (5), multiplied by 60 to reduce it to minutes) involves squaring the length to each point to which it is desired to calculate the deflection, which is tedious in the field and gives no check on the calculations.

The deflections for even stations from Table I. using a 50-ft. chord are:

Sta. 9.. 96.1	= 0° 00′ 00″	Sta. 11..+ 50	= 0° 47′ 23″
" 10..	= 0° 00′ 02″	" 12..	= 1° 23′ 10″
" 10..+ 50	= 0° 05′ 49″	" 12..+ 50	= 2° 08′ 57″
" 11..	= 0° 21′ 36″	" 12..96.1	= 3° 00′ 00″

These deflections are found using the column of differences Inst. at 0 and 30 minutes as the rate of transition, remembering that each point is 3.9 ft. ahead of where the chord points would fall if measured from the P. S. These differences increase by 10 minutes and throwing the points ahead 3.9 ft. increases each difference 47 seconds they thus become 5′ 47″, 15′ 47″, 25′ 47″, 35′ 47″, 45′ 47″, etc., which added give the above deflections. The tables of Crandall, Talbot or Howard do not solve this problem. Professor Talbot's general formulae will solve it by the same method used by Mr. Sadler. In case there is no object in keeping the even station numbers the deflections are as follows:

	Instrument at P. S.	Instrument at P.C.C.		Instrument at P. S.	Instrument at P.C.C.
0 ft....	0° 00′	6° 00′	200 ft....	1° 20′	2° 40′
50 " ...	0° 05′	5° 25′	250 " ...	2° 05′	1° 25′
100 " ...	0° 20′	4° 40′	300 " ...	3° 00′	0° 00′
150 " ...	0° 45′	3° 45′			

These deflections are found in the columns, Inst. at 0, and Inst. at 6.

This table gives the deflections from any chord point to any other, which is often very useful.

This problem is found in Prof. Talbot's table, a = 2 where all quantities are calculated at 10 ft. intervals; the deflections are given for point of spiral only.

In Prof. Crandall's tables, all the quantities are found (except the deflection angles) for the end of spiral, but in order to find the deflection angles it is necessary to use a chord length of 30 or 60 ft.

To use Howard's tables it is necessary to use a chord length of 24.49 ft.

The tables of the above authors are for special cases only while Table I. is perfectly general. This feature would be clearly brought out if an attempt were made to set centers for bents in trestle work where a spiral is often an important feature.

Searles' Multiple Compound Curve.—The method of demonstration and making tables as developed above is applicable to the multiple compound curve as developed by Searles, Torrey, Fox and others. The form or curve used by these authors is shown in Fig. 3, using chords 100 ft. long. By omitting the sign of degrees the case is general.

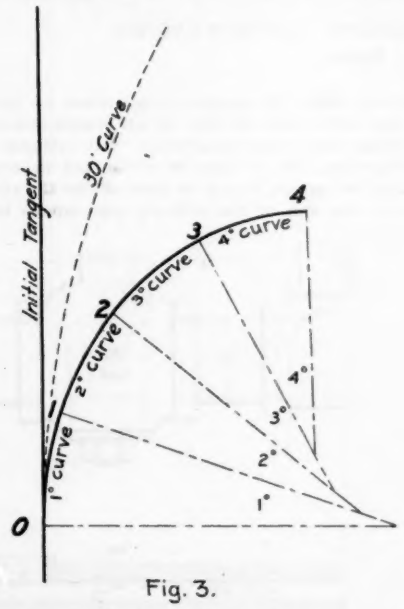


Fig. 3.

The difference in conception in this curve and the spiral described above is that in this case the angle subtended by the successive chords increases directly as the number of chords or as the distance from the point of spiral, while in the other case the degree of curve increases directly as the distance from the point of spiral. In the Searles' type the central angle of each chord is ½ r greater than in the railway spiral, and the degree of curve is ½° greater in each arc when the arcs are 100 ft. long. This amounts to starting the spiral with an initial 30-minute curve instead of 0 degree as in the other case, and Table III. can be made up by adding to each deflection coefficient in Table I., Inst. at 0, the deflection for a 30′ curve from the point of spiral to the desired point. Notice that the deflection increments in this case are ⅓ + 1-12 r, and the total deflection to any chord point is $\frac{1}{3}\triangle + \frac{n+1}{12}$ r. This would also reduce to ⅓ △ when the number of sides is infinite, but it is not used that way by the authors using this form of spiral, therefore, Table III. applies to a multiple compound curve.

The basis of the tables developed by Searles is an increase of 10 minutes in each chord angle, applying 10 minutes to the coefficients given in Table III. the results agree with those of Searles exactly up to the fifth chord and within two seconds at the tenth chord. Thus Table III. is applicable to any special case and is infiintely elastic, but the form of curve is faulty as can best be shown by an example.

Desired to connect a 6° curve to a tangent using a spiral 250 ft. long, and 25 ft. as a chord length. The eleventh chord then must subtend a 6° curve and central angle of 1° 30′, which, divided by 11 gives 8 2-11 minutes as the rate of transition, applying this to the coefficients in Table III., the deflections for instrument at Sta. 0 become 4′ 05″, 10′ 14″, 19′ 05″—2° 37′ 30″ for Sta. 10, or 250 ft. from Sta. 0. The total central angle is 7° 30′, which is found by multiplying the factor 8 2-11 minutes by the coefficient opposite Sta. 10 in column headed "Total central angle." If it had been desired to use a 50-ft. chord, then the 6th chord would subtend a 6° curve and a 3° central angle, and the rate of transition becomes 1-6 of 3° = 30′ and the deflection for Sta. 5 or 250 ft. from Sta. 0 is 2° 45′. Thus the position of the curve depends on the chord length, and may vary between the limits of a circular curve with but one chord length, when the deflection is ½ the central angle, and the true railroad spiral when the number of chords is great and the deflection is ⅓ the central angle, the central angle being constant in each case. This shows the multiple compound curve to be faulty in principle. There are said to be over 500 spirals calculated in the Searles' tables, yet these tables are comparatively rigid on account of the fixed chord length, for a given rate of transition.

The tables of Torrey and Fox are also solved by Table III.

The principal advantages in the above method of treating transition curves are as follows:

1. The simplicity in the method of demonstra-

TABLE III.—GIVING COEFFICIENTS FOR MULTIPLE COMPOUND CURVES.

No. of Point. n.	Degree of Curve.	Chord Angle.	Total Central Angle.	Instrument at 0 Def.	Diff	Instrument at 1 Def.	Diff	Instrument at 2 Def.	Diff	Instrument at 3 Def.	Diff	Instrument at 4 Def.	Diff	Instrument at 5 Def.	Diff	Instrument at 6 Def.	Diff	Instrument at 7 Def.	Diff	Instrument at 8 Def.	Diff	Instrument at 9 Def.	Diff	Instrument at 10 Def.	Diff
0	0			0		¼		1½		3½		6½		9½		13 5/12		18		23½		29½		36½	
1	1 c	1	1	¼	¼	0	¼	1	½	2½	1 1/12	5½	1 1/12	8½	1½	12	1 7/12	16 1/12	1 7/12	21½	1½	27½	1 11/12	33½	2 1/12
2	2 c	2	3	1½	1 2/12	1	1	0	1	1½	1	3½	1 2/12	6½	1 7/12	10½	1½	14½	1 11/12	19 2/12	2 2/12	25	2½	31½	2 1/12
3	3 c	3	6	2½	1 1/12	2½	1½	1½	1½	0	1½	2	1½	4½	1 11/12	8½	2 1/12	12½	2½	17	2 4/12	22 4/12	2 7/12	28½	2½
4	4 c	4	10	3½	1 2/12	3½	1 7/12	3½	1½	2	2	0	2	2½	2½	5½	2 1/12	9½	2 7/12	14½	2½	19½	2 11/12	25 7/12	3 1/12
5	5 c	5	15	5½	1½	5½	1 11/12	5½	2 7/12	4½	2½	2½	2½	0	2½	3	2½	6½	2 11/12	11½	3 1/12	16½	3½	22	3 7/12
6	6 c	6	21	7 7/12	2 1/12	8	2½	7½	2 7/12	6½	2 1/12	5½	2½	3	3	0	3	3½	3½	7½	3 1/12	12½	3 7/12	18½	3½
7	7 c	7	28	10	2 1/12	10 7/12	2 7/12	10½	2½	9½	2 11/12	8½	3 1/12	6½	3½	3½	3½	0	4	4	4	8½	4 1/12	14½	4 1/12
8	8 c	8	36	12½	2½	13½	2 11/12	13 7/12	3 1/12	13	3½	11½	3 7/12	9½	3½	7½	4	4	4½	0	4½	4½	4 7/12	9½	4 7/12
9	9 c	9	45	15½	3 1/12	16½	3½	17	3 1/12	16 7/12	3 7/12	15½	3½	13½	3 11/12	11½	4 1/12	8½	4½	4½	4½	0	5	5	4½
10	10 c	10	55	18½	3 5/12	20½	3 7/12	20½	3½	20½	3 11/12	19 7/12	4 1/12	18	4½	15½	4 5/12	12½	4 7/12	9½	4½	5	5	0	5

tion (which is precisely the same method as used in circular curves), gives the instrument man a clear idea of the curve, and shows how each quantity is made up.

2. The tables are short, perfectly flexible, are easily handled, and can be worked up in various forms to suit individual tastes.

3. The table of deflections can be pasted in any field book, and it is so simple that it may be reproduced in the field in a few minutes in case no table is at hand, thus it is not necessary to carry an extra field book relating to spirals only.

4. The instrument may be moved as many times as desired, and the spiral can be run in either direction, though it is better to begin with the instrument at the point of spiral.

5. Any chord length and any rate of transition may be chosen, which cannot be done with other tables. This feature is essential in bent work.

6. The table of co-ordinates is general, so that the tangent offset can be found for any point in any spiral.

In easing the ends of existing curves where tracks are not crowded, and where there is plenty of room to operate, almost any table will contain a suitable spiral, but often there are limiting circumstances which make it desirable or necessary to use a special spiral; this requires flexibility in the tables.

The above notes on the railway transition spiral have recently been worked out by the writer to be used in his own practice and have not yet been reduced to permanent form. This article is intended to point the way to simple demonstrations and flexible tables, rather than to present a finished result.

AN AUXILIARY AIR COMPRESSOR FOR STEAM ENGINES.

The great increase in the variety of uses to which compressed air is put in manufacturing establishments has led to a corresponding increase in the use of air compressors, and as many of these establishments already have surplus engine power there has come a demand for compressors which can be conveniently and economically operated by the steam engine which supplies the motive power for the plant. The Fisher compressor which we illustrate this week is especially designed to meet these conditions, and embodies a number of novel features.

From the view shown in Fig. 1, it will be seen that the air cylinder is intended to be attached tandem to the steam cylinder. The back head of the latter is removed and replaced by a one having lugs, into which are screwed the two attachment rods, and a stuffing box for the piston rod, which is screwed into the piston, taking the place of the tail rod on engines having this attachment. No heavy foundations are required, as the compressor cylinder becomes a part of the engine, and needs only to be supported at the proper level.

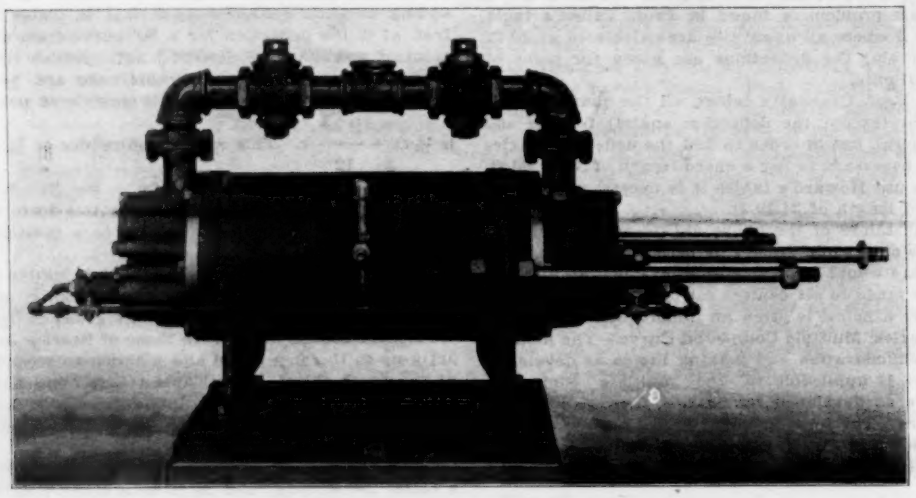


FIG. 1.—AIR COMPRESSOR FOR ATTACHMENT TO STEAM ENGINES.
Sedgwick-Fisher Co., Makers.

The small pipe shown at the side of the cylinder leads from the receiver to a chamber on each cylinder head, in front of the inlet valve. Upon this is an attachment containing a regulator or relief valve, which normally shuts off the receiver from the chamber. This may be set at any desired pressure. When the receiver pressure exceeds this, the valve is raised and air passes to the chamber, where it operates mechanism to keep the inlet valve open, so that the air simply follows the piston and is not compressed. The cylinder is double-acting, but in case of either end needing repair or attention, it can be shut off by the stop cock at that end of the delivery pipe above the cylinder. The machine then continues in operation as a single-acting compressor of half the capacity, while the head and valves at the end that is shut off can be removed entirely.

A longitudinal section of half the length of the cylinder is shown in Fig. 2. The outside shell (A) forms an annular chamber for the water jacket and through this is passed the feed-water on its way to the heater or to the boiler. The compressing cylinder (B) fits the jacket only at the flanges at (C), and here is one of the special features of the machine. The shell (A) is of the same diameter for all standard sizes, and the cylinders all the same diameter over their flanges, diameter of the barrels of the cylinders, howe varying to give various capacities. The object this is to enable the capacity of the machine to readily and quickly increased. It very often happens that too small a compressor is ordered, else the extending use of the air goes beyond capacity of the machine. In this case, the head can be removed, the cylinder withdrawn, a larger cylinder inserted, the diameter at being constant, as already noted. The admiss and delivery valves (D) and (E) are of tool s instead of brass, and have a life of three to f years. The valves and valve seats are inte changeable for all sizes of compressors.

The fitting for the relief valve, above mentioned, is shown at (F), and from this a pipe (G) leads to the chamber or cylinder (H) attached to the cylinder head in line with the admission valve. When the pressure in the receiver exceeds that at which the valve is set, the valve lifts and admits air through the pipe (G) to cylinder (H), where it acts on the piston head of the plunger (J), and drives the latter out against the valve stem, so that the valve is held off its seat, and the compressor piston moves freely without compressing any air. When the pressure falls, the relief valve closes, and an exhaust from the cylinder (H) is opened, allowing the air to escape. A coiled spring then draws back the plunger (J) into its chamber.

The weight of the compressor is only about 20% of that of an ordinary compressor plant, and it utilizes the surplus or excess power of an engine already installed, so that it is economical in first cost and in operation. Several of the compressors are now in use, all on Corliss engines. They have been installed by the Maryland Car Wheel Works, of Baltimore; the car and car wheel shops of the Armour Packing Co., of Kansas City, and in the works of the Featherstone Foundry & Machine Co., of Chicago. The Chicago, Burlington & Quincy R. R. has also installed two at its shops at Aurora, Ill., and Creston, Ia., the former being 7 × 42 ins., and the latter 10 × 24 ins. The weight of the former is about 1,025 lbs., complete. This compressor has been invented and patented by Mr. A. J. Fisher, and is being manufactured by the Sedgwick-Fisher Co., 53 South Clinton St., Chicago, Ill.

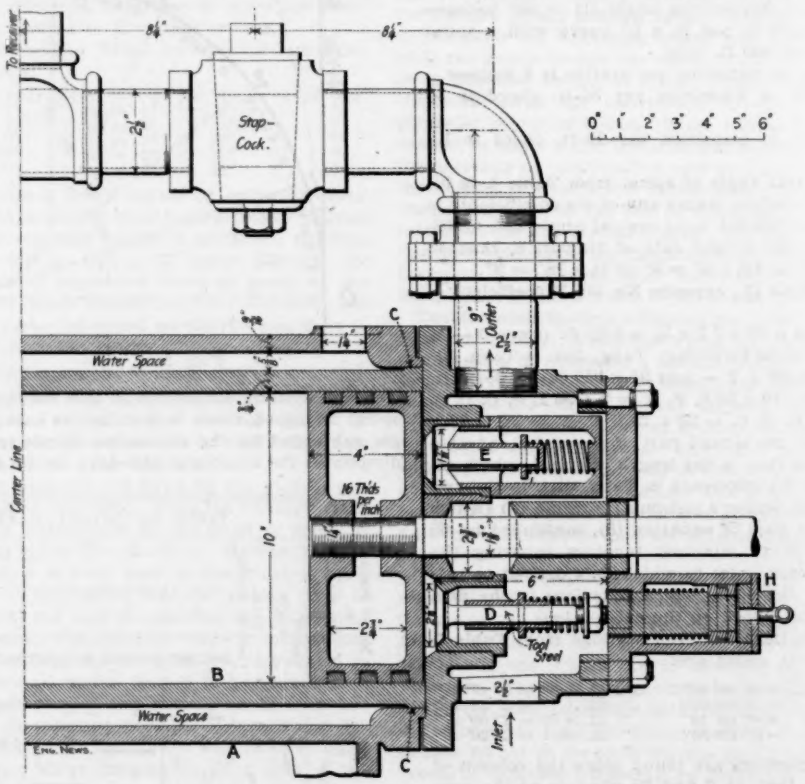
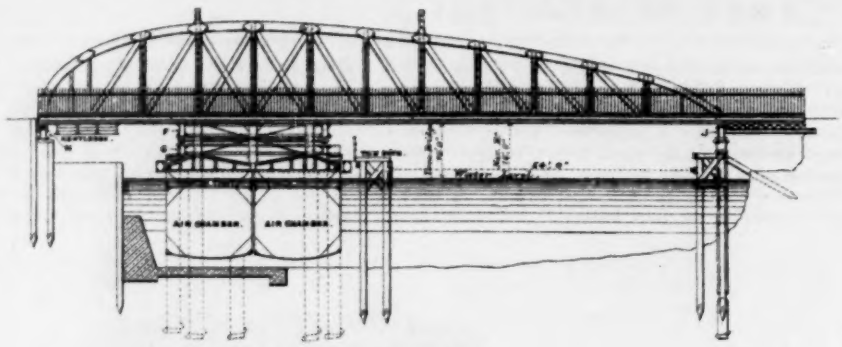
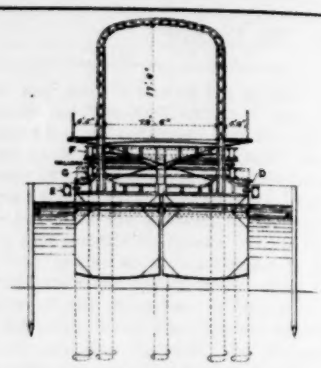


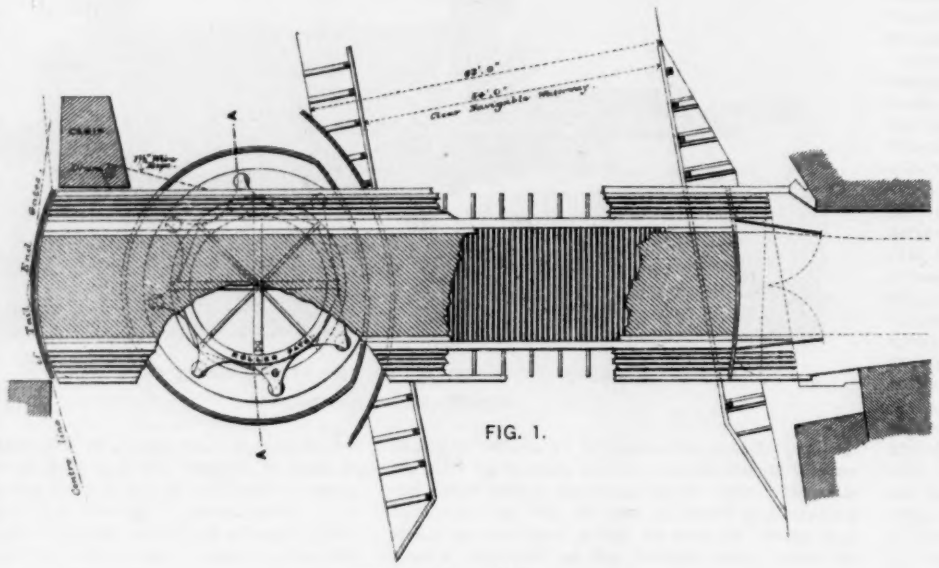
FIG. 2.—PART SECTIONAL ELEVATION OF AIR COMPRESSOR FOR STEAM ENGINES.



SECTIONAL ELEVATION.

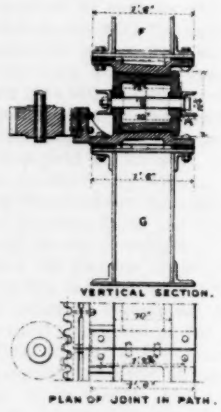


CROSS SECTION ON A A.



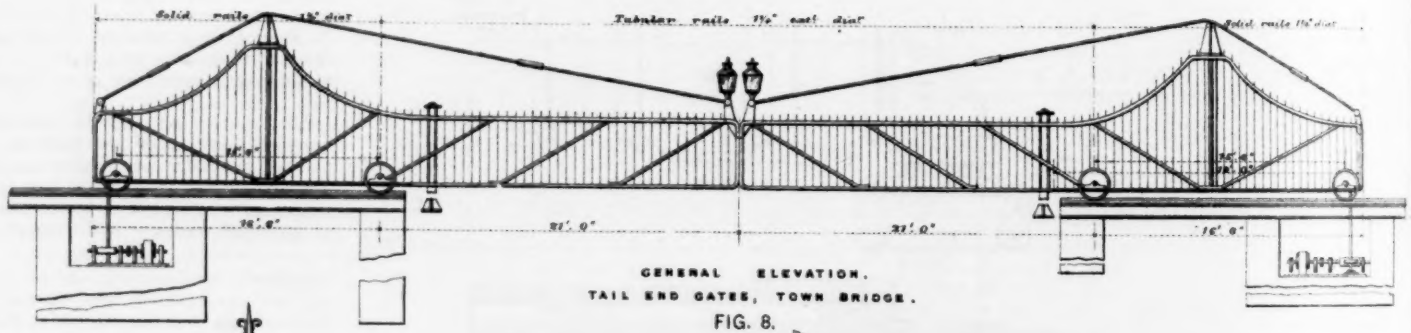
SECTIONAL PLAN.

FIG. 1.



PLAN OF JOINT IN PATH.

FIG. 3.



GENERAL ELEVATION.
TAIL END GATES, TOWN BRIDGE.

FIG. 8.

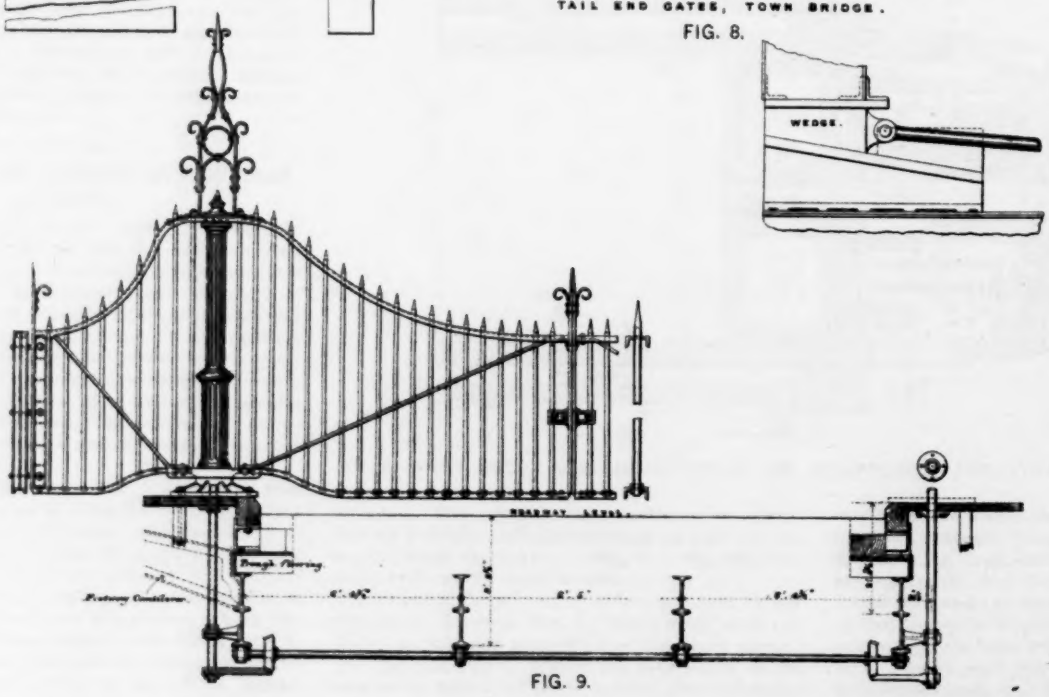


FIG. 9.

WEDGE.

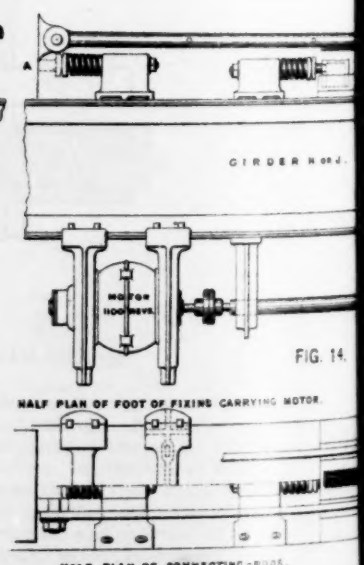


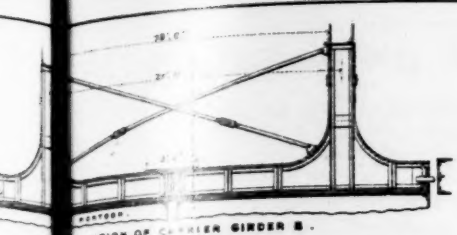
FIG. 14.

HALF PLAN OF FOOT OF FIXING CARRYING MOTOR.

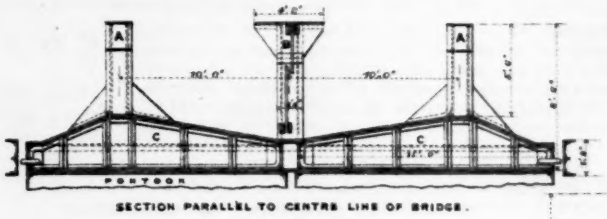
HALF PLAN OF CONNECTING-RODS.

PONTOON SWING BRIDGE OVER THE R ER WEAV

John Arthur Saner, M. Inst. C. E., gineer We

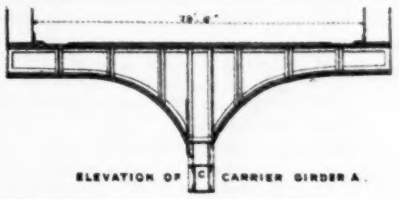


ELEVATION OF CARRIER GIRDER B.

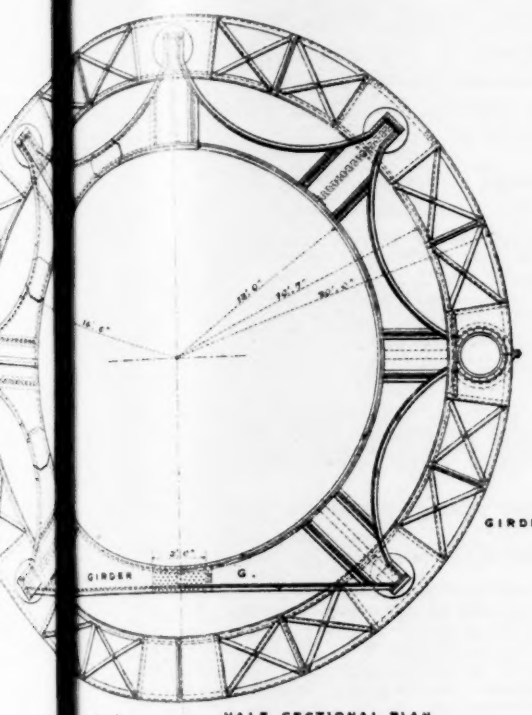


SECTION PARALLEL TO CENTRE LINE OF BRIDGE.

FIG. 2.

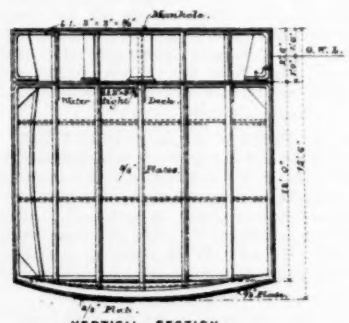


ELEVATION OF CARRIER GIRDER A.

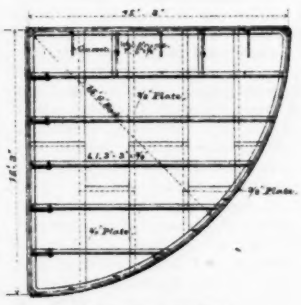


PLAN. HALF SECTIONAL PLAN.

FIG. 4.

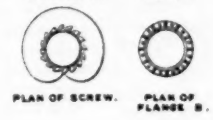


VERTICAL SECTION.



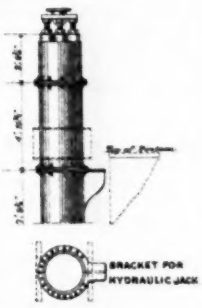
HORIZONTAL SECTION.

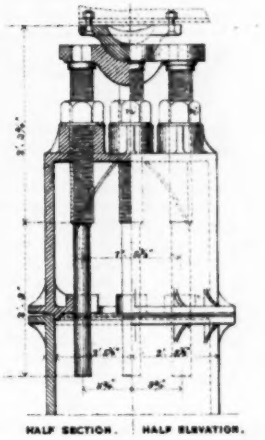
FIG. 5.



PLAN OF SCREW. PLAN OF FLANGE B.

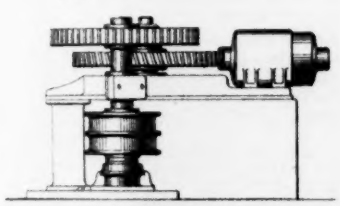
FIG. 6.





HALF SECTION. HALF ELEVATION.

FIG. 7.



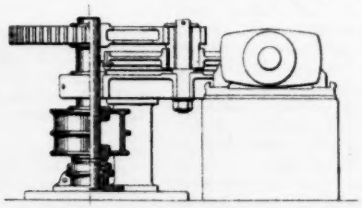
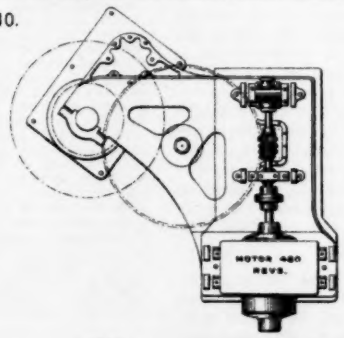
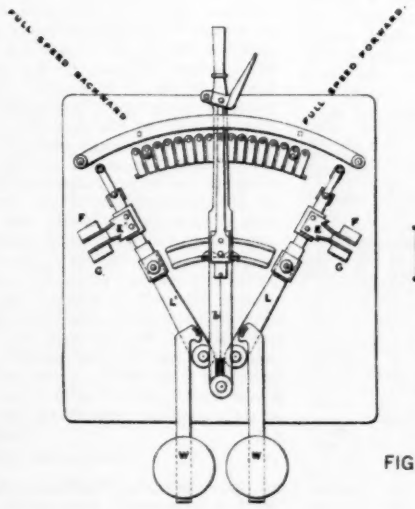


FIG. 10.





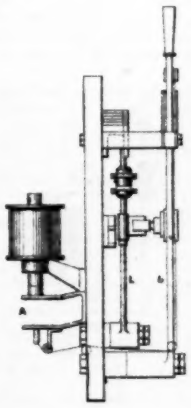
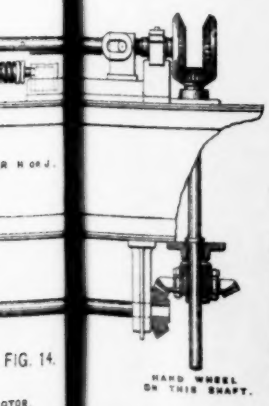
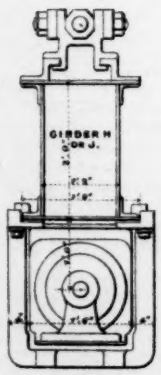


FIG. 11.





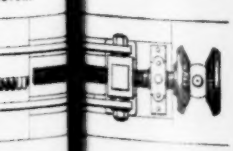


FIG. 14.

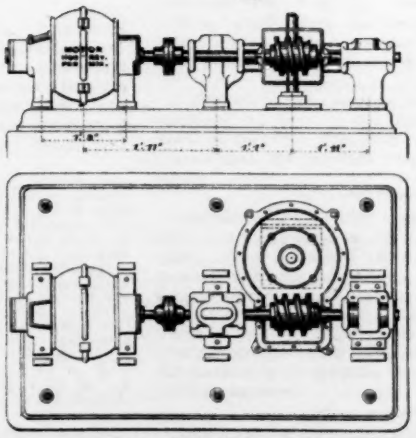
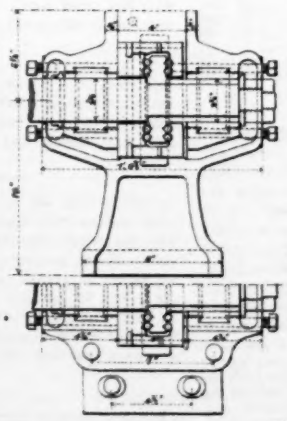
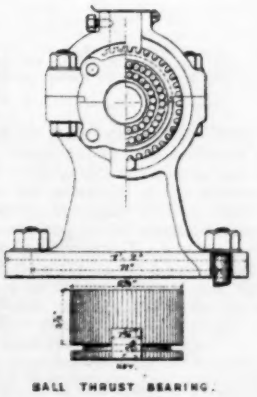


FIG. 12.



HALF PLAN.



BALL THRUST BEARING.

FIG. 13.

THE R ER WEAVER AT NORTHWICH, ENGLAND.

. C. E., gineer Weaver Navigation, Designer.

CHAS. HART, LITH., 26 VESEY ST., N. Y.